EQUITY ORIENTED PRACTICES IN A COLLEGE LEVEL PRE-CALCULUS CLASSROOM

A thesis submitted to the faculty of
San Francisco State University
In partial fulfillment of
the requirements for
the Degree

Master of Arts

In

Mathematics

by

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San Francisco, California

May 2018

CERTIFICATION OF APPROVAL

I certify that I have read Equity Oriented Practices in a College Level Pre-Calculus Classroom by Diana Zambrano, and that in my opinion this work meets the criteria for approving a thesis submitted in partial fulfillment of the requirement for the degree Master of Arts in Mathematics at San Francisco State University.

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2018

Equity-oriented practices have been studied and researched primarily in the K-12 setting (Rubel, 2017). The examples of these practices in college have mostly been studied in developmental math courses (e.g. Frankenstein, 2014). College instructors express the concern that topics relating to social justice are too controversial or that integrating them into math courses will take time and focus away from the mathematics that students are supposed to learn. In this study, I designed and enacted three lesson lessons for college pre-calculus, each incorporating different aspects of equity-oriented pedagogy. The students' experience in these lessons were compared with student experience in more standard pre-calculus lessons on the same topics taught by the same instructor in another section of the course.

Results show that students did have different experiences between the two sections section using the social justice lessons, with higher rates of feeling supported and that they belonged as members of the classroom than in the traditional lessons. These students also indicated more frequently that they found the mathematical content relevant to their lives. The two classes had a similar distribution of course grades and results on a common cumulative assessment indicated that that the introduction of equity-oriented lessons did not hinder students' mathematical learning. This work indicates that it is worth continuing to investigate the use of equity-oriented lessons at the college level. This will require investing in professional development for both instructors and students to be able to comfortable facilitate and engage in these lessons.

I certify that the Abstract is a correct representation of the content of this thesis.

Kathy H Swan 5/23/2018

Chair, Thesis Committee Date

PREFACE AND/OR ACKNOWLEDGEMENTS

First, I would like to thank my academic family. None of this work could have been accomplished by my main advisor, Dr. Kim Seashore. Thank you for your patience and for allowing me to think creatively and fully express myself. I would also like to thank, Dr. Sherria Taylor a.k.a. Dr. T. I met you at a time that could not have been more perfect. Thank you for speaking your truth and for showing me that I belong in a doctoral program. Lastly, I would like to thank Dr. Federico Ardila. Thank you for investing in my ideas and for giving me space in the classroom to do so. I look forward to our work together on this path towards justice.

Next, I would like to thank my *familia* and las *comadres*. Dr. Miguel Lopez, thank you for helping me navigate through this thing called higher ed. Your continuous support has really taught me the ways that I plan to support my students and to take care of our *comunidad*. Sandra and Patrick, thank you for being my source of strength during grad school. I am truly blessed to have you both in my life. Most importantly, I would like to thank my mom and dad for showing me the kind of educator I hope to be as I move forward in my career.

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Introduction

***Papelito Guardado* (Hidden Paper)**

School: Go get an education so you can be somebody.

Diana: *Well, that sounds like a good deal. These are pretty much free classes. That tarjeta* (card*) is soon to be mine.*

School: All you need is a brain, a stylus, some paper, and just do the time.

Diana: This sounds like a piece of cake. I can taste the better life. *No need to mop floors like mom. Those benefits are soon to be mine. Better job, better life, plus it's math, I wouldn't dare be so dumb as to step out of line…. Damn, dame la tarjeta, I will be a mathematician in no time… Then surely, I will be somebody.*

University Math Professor: If you take the Latinos out of the equation, America's mathematical performances would go up. In fact, we would be in par with Finland.

Diana: *Oh wait, what the fu…*

White university math student: Not to sound racist, but it's not fair that I am stuck with these thugs and their parents who don't care about their education.

Diana: *Wait, hold up you're talking about my parents. And so, I put la tarjeta down. I looked around at the white faces in the room, and through their silence I came to realize it seemed like they could care less.*

Diana (a year later): *My membership is almost solidified now with more benefits to come. Damn, I've almost "made it in Gringolandia!" Can't step out of line now.* Take good notes Dee! *But he said our lives begin to end the day we become silent about the things that…* Not now Dee. That doesn't matter.

School: Put the card back in your pocket. We need you to hold onto this membership because the benefits will be multiplying, soon you will *be somebody*.

Diana: He said, "Look at that ass," as we made our way up the stairs. *I thought coming out to you would have been liberating? I thought it would put a stop to all of the "that's so gay" name calling. The spike in my blood reached the outermost layers of my core. Wanting to scream., all I can say is,* Dude. I don't see women the way you do! *Realizing we are not on the same team. I hold my membership card up to the light… to see what might be written in the fine print… Wondering, I hate that I need his help in order to get to that better life. So, I can be somebody.*

Diana (days later): *This card in my hand feels like it has its own weight and sharp edges. The harder I hold onto it, it feels like I am taking …*

School: Focus Dee. Look you're a mathematician, you've got that degree.

Diana: *But can't you see the damages the my…?*

School: Quit your complaining. Can't you see you're finally a somebody?

Diana: *So, as I sit in my math class, he, she, he, then she again says* "as Sandra was saying…" *But my name is Diana. Can't you see my name? It's on my card! I have to have a joke handy as a way to lessen the stress… to minimize the shame… for when you interchangeably calling me the other brown woman's name. So, I look down to check my card, to see which name is on it. They told me to come here, so I can be somebody, the somebody who shall forever remain card-less.*

My View on Equity

I take the idea of *papelitos guardados* from the Latina Feminist Group in order to shed light in the ways in which I have been marginalized during my participation in the STEM field as a mathematician (Latina Feminist Group, 2001). I do not bring this to the

forefront as a way of bringing my baggage to my work, but rather to let reader see how I conceptualize and think about equity. Thus, shedding light in the ways that I seek to interact and pay close attention to my students' *historias* (histories).

Statement of the Problem

The STEM field presents a lack of diversity, which has underpinned several initiatives by many organizations, scholars, and researcher's intent on addressing this concern. For example, in the year 2016, a 15mn-dollar investment was ordained to the San Francisco State University and correspondingly the following year, SFSU received a million-dollar grant (Morales, 2016). This is clearly indicative of an intention to get more underrepresented students in the STEM field. But concurrently, it is critical to examine why it is that we want to see more numbers of certain types of students in these fields. In addition, scholars must ask how they plan to go about that it all while being mindful of the concept of intention versus impact. Tarra Yosso calls to action that educators should effectively help students to navigate through the system rather than the students having to negotiate something of themselves (i.e. leaving their native language at the door, conforming to heterosexual, gender, societal norms to fit in) (Yosso, 2013). Case in point to explicitly demonstrate what Tarra Yosso means by negotiation is when students grow up being told, 'Go to school, go to college, so that you can be somebody.' Well what does this indirectly tell a first-generation college student? In other words what does that say about their mom? Their dad? Their grandmother? Their grandfather?

One of the several ways in which scholars are trying to engage in this plan of action, is through the optimal and opportune application of Equity-Oriented Practices, which will be explained in more depth in Chapter Two. Some scholars believe that building a connect of the curriculum and teaching methodology to students' lives would increase student engagement and it would help them better understand the mathematics necessary for them to learn. Particularly, there are lesson plans that discuss the topic of racial profiling, and I, as an instructor, have been assigned the responsibility to integrate it and

classroom learning and implement the same. Again, we must be critical of the impact of these lesson plans as we potentially induce traumatic events from the students' lives. My question to scholars and educators is how would you seamlessly with maximal impact and minimal adverse result carry or implement a lesson on racial profiling if Stephon Clark's children were one day sitting front row in your classroom as one of your students? What intellectual or emotional concerns would you have if you were implementing a racial profiling lesson and one of Trayvon Martin's siblings was one of your students? Because quite honestly, I am sure they do not need to master the mathematics to get the horrific truth that they have already experienced. The sad truth that racial profiling can be statistically proven. So, we must be mindful of how we intend to connect with our students and identify the ideal means. This goes beyond just teaching math only for math sakes.

Purpose of the Study

The goal of this study is to implement math for equity-oriented pedagogy in a class other than a developmental math course. By elaborating on this objective in the current study, I wanted to create a space in the classroom that welcomes a student's identity, while also getting to the dominant mathematics. I attempted to do this through the design and implementation of three equity-oriented lessons and compare students' experiences of these lessons with the experiences of students in using a more standard lesson plan. Chapters two is a review of relevant research literature in the theory and implementation of equity-oriented mathematics instruction and frames the contribution of this study. Chapter three outlines the context, data collection, and analytic methods for this study. In chapter four, I provide detailed descriptions lessons that were implemented in the Social Justice Pedagogy section. In chapter five, I describe the results of students' participation in these lessons, through the analysis of post lessons surveys, responses to homework assignments, course grades, and their performance on the Mathematics Diagnostic Testing Project Calculus Readiness Assessment. Chapter six is a discussion of the results

from chapters four and five, with implications for future use of lessons designed to integrate social justice and mathematical learning.

Research Questions

The research of the implementation of these three equity-oriented lesson plans is intended to address the following three research questions:

(i) How was equity-oriented pedagogy integrated into the three lessons in the social justice section of pre-calculus?

(ii) How did students' experiences in the three equity-oriented lessons affect their perception of membership, support and relevance in their math class?

(iii) How did the additional time spent on the three lessons in the social justice pedagogy class affect the students' learning of mathematical content?

Chapter 2

Conceptual Framework

Since 1990, a growing number of educational researchers and teachers have been developing theories and pedagogical strategies for promoting more equitable learning opportunities and outcome for the diversity of students in public education. Broadly grouped, these theories are called Equity-Directed Pedagogies (Rubel, 2017). In mathematics, the research and practice involving equity-oriented pedagogy is particularly important because of large and persistent disparities that exist in learning outcomes based on student demographics. These disparities are usually reported in terms of standardized test scores, rates of enrollment or completion of mathematics courses, representation in honors or advance courses, and matriculation in STEM majors in college; these traditional objectives are what Rochelle Gutiérrez defines as dominant mathematics. While researchers are concerned with these outcomes, their goals are broader and more wide reaching. This is what Gutiérrez defines as critical mathematics, that deals with notions of identity and power (Gutiérrez, 2009). Scholars in this area have also placed substantial focus on students use mathematics to examine inequity in society and developing mathematical knowledge that could promote a more just and equitable society. This dual focus on learning the mathematics both to pass courses and pursue STEM majors and career as well as to increase socio-political consciousness and justice is frequently referred to teaching math for social justice (MSJ) (Frankenstein, 1990). The following literature review aims to provide a background on research and emerging theories of equity-oriented pedagogies in mathematics, including culturally relevant pedagogy and mathematics for social justice with a focus on their relevance for teaching entry-level college mathematics at a diverse public university.

Equity-oriented pedagogy is an umbrella term that includes a variety of approaches to teaching across subject and grade levels from kindergarten through university. Of these approaches, the following theories were most influential in the design of the lessons and

research in this study: culturally relevant or culturally sustaining pedagogy (Ladson Billings), mathematics for social justice (Gutstein and Frankenstein), building on shared experiences (Moses).

Marilyn Frankenstein conceptualized and pioneered teaching math for social justice with students in developmental level college courses with working class adults (Frankenstein, 1990). Her work was strongly influenced by Paulo Freire's, *Pedagogy of the Oppressed,* 1970, in which he argues that critical education involves problem posing in which all involved are challenged to reconsider and recreate their prior knowledge (Frankenstein, p. 316). Frankenstein's critical mathematics pedagogy focused primarily on using statistical tools to analyze social issues (i.e. income data, home mortgage distribution, tax system). She intended to promote MSJ by giving the students, "the ability to ask basic statistical question in order to deepen one's appreciation of particular issues [and] it also involved the ability to present data to change people's perceptions of those issues" (Frankenstein, 1990, p.336). Her work emphasizes the importance of using context that are meaningful, socially important and appropriate for adult students in the context of learning even the most elementary mathematics.

In 1995, Gloria Ladson-Billings coined the term *culturally relevant pedagogy* (CRP) to describe teaching that focused on the following objectives: 1. to produce students who can achieve academically where achievement is not limited to standardized tests, 2. to produce students who demonstrate cultural competence, and 3. develop students who can both understand and critique social order. (Billings, 1995). As a pioneer of CRP, Ladson-Billings' claimed that teachers should provide students with "a way to maintain their cultural identity while succeeding in academically" (Ladson-Billings, 1995, p.476) This is how she defined developing students' cultural competence.

Along with promoting cultural competence, Ladson-Billings argues that educators must provide students with the tools to understand the social structures around them (Ladson-Billings, 1995). For example, students can explore how institutional racism

might affect their lives, and thus the students are taught on how to challenge those structures. Even though Ladson-Billings conceptual framework of CRP is not specifically referring to the teaching of mathematics, math education researchers similarly argue that "teaching entails a shift from thinking of preparing students to live within the world, as it currently exists, to thinking about how to prepare students to restructure "those social systems… in order to remove barriers that women, minorities, and others experience"(Secada, 1989, p.47) As previously mentioned, Ladson-Billings theory does not specifically address mathematical teaching, but it does serve to highlight work that centralizes race, culture, and power.

In 2014, Ladson-Billings revisited the theory of CRP (Ladson-Billings, 2014). This was primarily done to shed light on how her concept of CRP has been misused in practice. While discussing this, she also updating the term to *culturally sustaining pedagogy* (CSP), which is accredited to Django Paris, in order to highlight the following changes in her framing of the theory (Paris, 2012). CSP makes an important shift from what people think of as culturally relevant pedagogy. Instead of focusing on one singular racial or ethnic group, Paris pushes researchers to, "consider the global identities that are emerging in the arts, literature, music, athletics, and film. Is also points to the shifts of identity that now move us toward a hybridity, fluidity, and complexity never before considered in schools and classrooms" (Ladson-Billings, 2014, p.82).

While Ladson-Billings has been tremendously influential in the area of equity-oriented pedagogies, she has not been specifically focusing on the teaching and learning of mathematics. The MSJ goals of increasing student's proficiency in dominant mathematics and increasing student socio-political consciousness, are similar to Gutiérrez' re-humanizing-oriented framework, which attempts to construct such a practice using two dimensions: *dominant mathematics* and *critical mathematics*. Rochelle Gutiérrez defines and uses these two axes for reframing and measuring equity in mathematics education. She defines a *dominant axis* comprised of a traditional form of

measure through access (i.e. resources available to students) and achievement (i.e. mathematical proficiency, exams scores, enrollment rates, etc). She also defines a *critical axis* composed of identity and power (Gutiérrez, 2009). When it comes to notions of identity, Gutiérrez states that curriculum should uphold a window/mirror approach. She articulates that through the curriculum, students should be able to see themselves reflected in it, but also see beyond the curriculum as well. This notion of seeing beyond is in reference to being agents of social change (Gutiérrez, 2009).

Two projects that stand out for their working in putting the theories of equity-oriented pedagogy into practices are the Robert Moses' Algebra Project and Eric Gutstein's' teaching of Mathematics for Social Justice. The approaches that Moses and Gutstein take to promoting equity demonstrate different ways that these theories can be considered in implementation. In 1982, building on his experience working for voting rights in the south during the civil rights movement of the 1960's and 70's, Robert Moses decided that mathematical literacy and access to college-preparatory mathematics was a new frontier in civil rights. He observed that white students were being accelerated into Algebra 1 classes in the 8th grade at far greater rates than black students and that this difference was a precursor to increasing divergence in educational opportunities through high school and college (Moses, 1989). He used his experience with organizing to create a new movement focusing on curriculum development, research, youth organizing, and peer mentorship. The classroom component of this work was the Algebra Project curriculum and pedagogy. His theory of action was that students needed to begin their study of a new topic with shared experiences that would allow them to discuss emerging mathematical ideas with each other in their own words. Standard mathematical vocabulary and symbolic notation would be mapped onto their mathematical ideas as the need emerged and only after students had a chance to make sense of these ideas in their own language (Moses, 1989). The focus of Moses' Algebra Project was on increasing African American students access and opportunities for success in dominant mathematics in order to eliminate a barrier to college and careers that required quantitative literacy.

Rico Gutstein approaches EOP from a slightly different perspective. While he agrees with the importance of providing access to the dominant mathematics, he also believes that students needed to learn to see math as a tool for understanding and changing inequity in the world around them (Gutstein, 2016). Like Frankenstein, Gutstein's work is strongly influenced by Paulo Freire's idea of reading and writing the world (Frankenstein, 2002). Gutstein enacted a form of SJM in a Chicago public middle school with predominantly low-SES Mexican and Mexican American population. For Gutstein SJM encompasses four factors: 1. academic success 2. sociopolitical consciousness 3. a sense of social agency 4. Positive social and cultural identities (Gutstein, 2016).

In order to achieve this goal, Gutstein developed 17 real-world mathematics projects that connected to student's lives. One such lesson discusses matters of a living wage, by first inviting them to ask their own meaningful questions. Then students discussed and defined what a living wage means to them. Additionally, they were then given occupational assignments/scenarios to see how those corresponding hourly pay rates would play out. This created an opportunity for students to share their own personal stories about their parents, where some stated had to work two jobs to make ends meet (Gutstein & Peterson, 2005).

Both Frankenstein and Gutstein's see their work as promising. For example, Frankenstein discovered that her critical mathematics pedagogy changed her students' perceptions of mathematics and their ability to understand math and she engaged students in using math to analyze their world (Frankenstein, 1990). Similarly, Gutstein claimed promising results based on the classroom environment where students began to become more engaged by consistently raising their own questions, which seems to show a sense of agency among students (Gutstein, 2016). In the end these results are measured to be promising through teacher observation. There is little quantitative data presented that helps make the argument that SJM goals were achieved in Rico and Frankenstein's classes.

In this study, I draw on the work of the scholars discussed above in the following ways. I define math for social justice to uphold two dimensions, which is that of critical mathematics and dominant mathematics. At the time of developing the lesson plans I had an original definition of CRP which blended with Gutiérrez notion of a curriculum that upheld a window/mirror effect (Gutiérrez, 2009). I plan to do this at a rather diverse public university, SFSU. Kari Kokka discusses the dynamics of implementing such pedagogies in different environments where students come from different socio-economic backgrounds (Kokka, 2017). Hence, these lessons may play out very differently in a different part of the United States.

I also define CRP to uphold both dimension of dominant mathematics and critical mathematics as Ladson-Billings definition illustrates. For lesson 1, I attempted to extract the math out of the textbook and connect it to students' lives. This lesson followed similar objectives to that of Gutstein's Living Wage lesson with his students (Gutstein, 2005). But I wanted to make sure that there was a plan of action with this lesson, which resulted in creating an additional homework at the end of the semester where students wrote a letter to their senator using the mathematics they mastered. Lesson 2, is where I attempted to find my own connection to composition of functions through this idea of misrepresentation. Lastly, lesson 3 deliberately incorporates aspects of dominant mathematics in hopes to help produce students who can achieve academically beyond standardized assessment.

In this study I hope to contribute to the math educational field by enacting equity-oriented practices in a non-developmental course at the college level. I hope to document students' reactions to the implementation EOP. I plan discover ways to quantitatively measure the factors that EOP entails. Lastly, I hope to explore the ways where we can challenge the level of criticalness that many scholars claim to have in their classrooms by providing a tool to measure this concept if such tool exists.

Chapter 3

Method

This study was a comparative self-study where I wanted to see how equity-oriented pedagogies enhance students' experiences in college level classes at San Francisco State University. More specifically, I was curious of seeing how this would be implemented in my precalculus course. For this study I had three specific research questions:

(iv) How was equity-oriented pedagogy integrated into the three lessons in the social justice section of pre-calculus?

(v) How did students' experiences in the three equity-oriented lessons affect their perception of membership, support and relevance in their math class?

(vi) How did the additional time spent on the three lessons in the social justice pedagogy class affect the students' learning of mathematical content?

3.1 Context and Participants

The participants in this study were students enrolled in Math 199: Precalculus at San Francisco State University (SFSU), a large, urban public University. It is a class that meets four times a week for 50 minutes each time. In 2017 the campus had roughly 30,000 students in which 55.8% students were female. Of those 30,000, Latino's made up 37% of the population, Asian made up 28.9, Black, African American students made up 6.1%, and White Non-Latino made up 20.3%. Math 199, is taken predominantly by freshman and sophomores who are majoring in a STEM field and plan to enroll in Calculus 1 (Math 226). The first-time freshman population at SFSU makes up for 53.8% of the population while 37.7% of that population are first generation college students.

The following is the course objectives as defined by San Francisco State University's Math Department:

> This course assumes that students are familiar with intermediate algebra and have at least a rudimentary knowledge of basic trigonometry. The principle objective of Precalculus is for students to be prepared to take calculus. Students will learn more advanced algebraic techniques, the concept of functions, and techniques for graphing. Students will also learn the properties of exponential and logarithmic functions including their graphs and their applications to scientific problems. Finally, students will learn how to solve a variety of problems involving the properties, graphs and identities of trigonometric functions. An important focus of the course is for students to engage in realistic problem-solving as opposed to rote memorization (Math 199 Course Objectives, 2016).

For this study, I compared and analyzed my class in which I was the assigned instructor, **Social Justice Pedagogy (SJP) section** and Emilio's class, **Standard section**, in the Spring of 2017. From the SJP Section, I recruited 32 of the 40 (80%) students enrolled in my class. I recruited 20 of the 34 (59%) students in the Standard Section. The majority of students from both sections were freshman and sophomores.

Instructors

As previously mentioned, this was a comparative self-study, in which I observed my own class along with a colleagues' classroom. Because the instructors for Math 199 at SFSU are predominantly graduate students from the math department, I was selective with choosing a colleague for this study. I chose Emilio due to his teaching experience with Math 199. Emilio had taught the subject at SFSU for 2 semesters prior to the study, and I had taught it for one semester prior to the study. Emilio's class for the sake of this study is referred to the Standard section. But it is worth mentioning that I labeled Emilio's class "Standard" based on Emilio's standards. Additionally, both Emilio and I identify as queer LatinX students and educators.

Procedure

Becoming an Active Participant in Emilio's Class.

For this comparative study, I taught lessons in both the Standard Section and the SJP Section. There were days in which I lectured in Emilio's class for the purpose and documentation of this study, but this does not imply that I only participated in Emilio's class three times as an instructor. There were instances in which I subbed in for Emilio, and I also participated as an audience member, where sat in his class weekly. This was done in order to fully support students regardless of the study I was conducting. Sitting next to the students allowed me to answer questions if they had any and build rapport. In addition to providing additional support in the classroom, I also invited Emilio's students to my office hours.

I taught three topics in both sections: Linear Functions, Composition of Functions (C.O.F.) and Introduction to the Unit Circle. These topics were covered roughly three weeks apart.

The execution of the equity-oriented practices in each topic were different. The following figure helps illustrate that process. The exit ticket consisted a free response question and a survey.

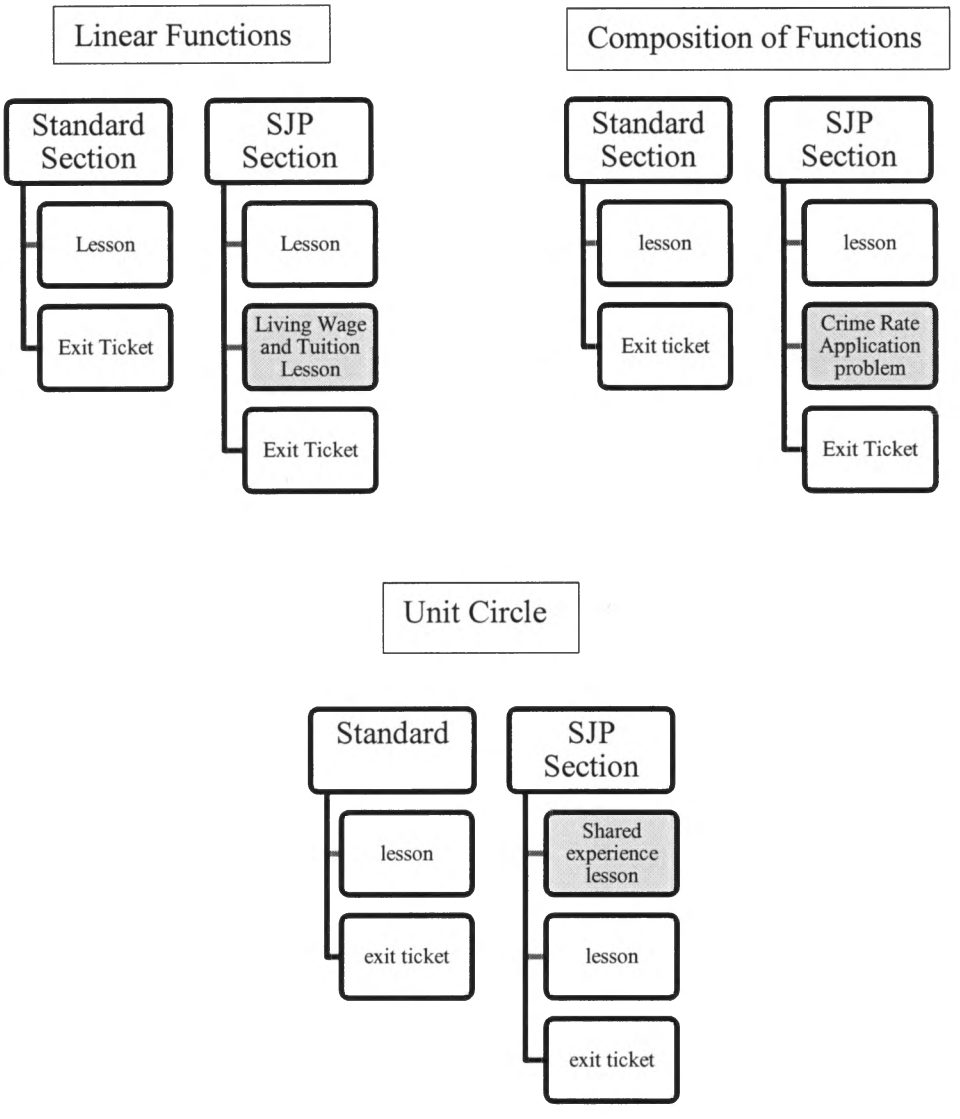


Figure 1. Comparison of lesson segments between Standard and the SJP sections.

Materials

The Lessons

The class ran for 16 weeks. As shown in figure x, the pink shaded figures indicate the EOP that I implemented in the SJP section throughout the semester. Those lessons were:

- Linear Functions: Tuition and Minimum Wage

- Composition of Functions: Misrepresentation
- Shared Experience: Special Right Triangles and the Unit Circle

Linear Functions: Tuition and Minimum Wage

For this topic, I gave Emilio's' students and my students the same 50-minute lecture prior to implementing the Eric Gutstein inspired lesson in my SJP classroom. It was with this equity-oriented lesson, that I wanted to play with this notion of linear functions on a more personal level. Students were assigned a reading by members of the Faculty Association, "Equity Interrupted."

Composition of Functions (COF): Misrepresentation

Both Emilio's students and my students were exposed to the same lecture that implemented a relay game. The difference is that my students in the SJP section were given a more personal application of COF.

Shared Experience: The Unit Circle

Both sections were given the same lecture/ introduction into the unit circle. The only difference is that my class had the shared experience prior to the unit circle introduction., where they were exposed to special right triangles and their properties. Students from both sections were asked to research the following terms before the unit circle introduction: Pythagorean theorem and equilateral triangle.

HomeWorks

Homework 3.5: Students were required to fill out a scholarship profile with San Francisco State University and students were assigned to read and reflect on the reading, "Equity Interrupted."

Homework #10, Composition of Functions: Students were asked to use their imagination with a low stakes homework where they were encouraged to re-write a narrative using themselves.

Additional Means of Support

Because we discussed issues that students face in higher education, I created assignments to further support students as we worked on the curriculum.

- **Article Debriefing**: Half a day was spent on facilitating a discussion on how students felt about the topic of minimum wage and tuition. Students were broken up into group of 3-4 people. They were given the opportunity to get into their own groups.

- **Letter to a Senator:** At the end of the semester, students were encouraged to write a letter to their Senator, discussing their stance on student tuition. I wanted students to use the mathematics to articulate their argument. Given that some students in my classroom were undocumented, I made this assignment extra credit at the end of the semester.

Pre and Post Survey Across All Pre-Calculus Section

A 24-question survey was sent to all sections three weeks into the semester and three weeks prior to the end of the semester. For this study, I only analyzed the responses to the question: *Do you believe you would have a greater sense of belonging to Math 199 if the content of the math problems you were asked to solve were closely related to your everyday life? (Choose one: strongly believe, believe, do not believe, strongly do not believe).*

Exit Ticket: Free Response

At the end of each lesson in both SJP section and Standard section, students were handed an exit ticket, which was composed of two parts, a free response and a survey. For the free response, students were asked to respond to the following:

Briefly describe what you think were the important or big takeaways from today's class.

Coding for Exit Ticket: Free Response

Throughout each set of responses, I was generally looking for 1. Any identification of finding the lesson **relevant** or **personal** to student's lives or their world outside of class 2. **Mathematical Notation**/Equations or Formulas 3. **Mathematical Explanations** that showed further understanding of the concept being studied.There are some responses that counted for more than one category as students expressed a sense of relevancy to the topic being studied and demonstrated further understanding of the topic through mathematical explanation.

Please note that for table 1, table 2, and table 3 student examples are provided for the types of responses that accounted for the previously mentioned categories.

Table 1

Coding for Free Responses for Lesson 1

	S.J.P. Class	Standard Class
Personal Connection	it is important to learn linear functions because it helps us to see a constant rate of change. Linear functions helped to see how many hours I would need to work to break off even to pay tuition.	I learned how to apply math in my daily life. Which I think is very important.
Application/Relevancy	Students have to work a lot at a minimum wage paying	Learning about linear functions and how

	job to pay for college tuition.	they can apply to my life.
Math Notation	to find the slope or rate of change we use, $\frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1}$ Use $y = mx + b$ to find the y-int. Set x = 0.	$\frac{y_2 - y_1}{x_2 - x_1}$
Math Explanation	If there's a point and a rate of change, you will be able to find the equation or the missing part of the problem. Depending on rate of change is how much will be a.k.a. steep/not steep.	Order doesn't matter (when calculating slope)

Table 2

Examples of how some comments were coded when classifying student free responses.

Table 3

Coding for Free Responses for Lesson Two

	S.J.P. Class	**Standard Class**
Personal Connection	How to understand C.O.F., deconstruct them, and make them our own.	(None)
Application/Relevancy	How composite functions operate and how they relate to our lives on a daily basis.	(None)
Notation	The relation of mathematical concepts to the real world as well as obeying a workflow example $f\left(g\left(k(x)\right)\right)$.	$f \circ g = f(g(x))$
Comment/Explanation	How to find composition of a function. Work from inside to outside	The composition of functions can't be commutative

A new code, positive self-assessment, was introduced for lesson three where students from both sections, illustrated some sense of positive self-assessment. Table 3, obtains some examples of those student responses that fell under that particular category.

Table 4

Coding for Free Responses for Lesson Three

	S.J.P. Class	**Standard Class**
Relevancy or Personal Connection	(None)	(None)
Math Notation	(Student drew out the 30-60-90 and 45-45-90 triangles)	$a^2 + b^2 = c^2$ $\sqrt{\frac{a}{b}} = \frac{\sqrt{a}}{\sqrt{b}}$
Math Explanation	The unit circle is just made up of triangles or can be constructed with triangles. It's so crazy, no one ever told me that in my math high school classes. So cool!	Mirror the triangle (presented in class) and you get an equilateral triangle.

Exit Ticket: Survey

This questionnaire was attached to the backside of the Exit Ticket. This survey was not color coordinated for students. It is color coordinated below to show the coding used to measure factors of support, membership, and finding the lesson relevant.

Survey Questions

Please indicate how much you agree with the following statements.

Scale: 1= Strongly agree; 2=agree; 3=disagree; 4=strongly disagree

1. I felt supported by my peers today.

   (1) (2) (3) (4)

2. I felt supported by the instructor today.

   (1) (2) (3) (4)

3. I feel a sense of belonging to this classroom.

   (1) (2) (3) (4)

4. I feel like my contributions were valued in class.

   (1) (2) (3) (4)

5. I feel comfortable in this class.

   (1) (2) (3) (4)

6. I see myself as a member of this class.

   (1) (2) (3) (4)

7. I feel like an important member of this class.

   (1) (2) (3) (4)

8. I found today's lecture meaningful to my life.

   (1) (2) (3) (4)

9. I found today's lecture relevant to my life.

   (1) (2) (3) (4)

10. I can use today's lecture to better navigate in the world.

    (1) (2) (3) (4)

11. I feel that I can use what I learned today as a tool to explain concepts to other people.

    (1) (2) (3) (4)

In order to see a notable pattern in the Exit Ticket Survey, I grouped questions 1, 2, and 4 to measure students' sense of support during lecture. Similarly, I combined questions 3, 5, 6, 7 to measure students' sense of membership to the classroom, and lastly, I grouped questions 8,9, and 10 together to measure a sense of relevancy of the lesson to students' lives.

Table 5

Coding for measuring Support, Membership, and Relevancy

Category	**Selected Survey Questions**
Supported	1.I felt supported by my peers today. 2.I felt supported by the instructor today. 4. I feel like my contributions were valued in class.
Membership	3. I felt a sense of belonging to the classroom. 5. I feel comfortable in this class. 6.I see myself as a member of this class. 7.I feel like an important member of this class.
Relevancy	8.I found today's lecture meaningful to my life. 9.I found today's lecture relevant to my life. 10.I can use today's lecture to better navigate in the world.

After I grouped the set of questions as shown in table four, I took the average of each student's responses from each category. This would allow me to have one number assigned to one student when measuring support, membership, and relevancy. After taking the averages to every students' responses, I counted the total number of students who had an average score from 1-2. Recall, that on the exit ticket survey a score of 1=I strongly agree and 2= I agree. I did this in order to consider the student responses who

agreed (in respect to their averages) to have found the lesson relevant, felt supported and felt a sense of membership to the class after the lesson.

In chapter 4, I address the first of my research questions with the descriptions of how social justice pedagogy was integrated into the development of the three precalculus lesson.

Chapter 4

The Equity Oriented Lessons

In this chapter, I describe each of the three equity-oriented lesson that I developed and implemented in the Social Justice Pedagogy section of pre-calculus. Each description begins with a lesson intention, where I describe my thoughts in designing the lessons and articulate which aspects of equity-oriented pedagogy I intended to enact with the lesson. This address the first of my research questions: How was equity-oriented pedagogy integrated into the three lessons in the social justice section of precalculus?

In the lesson overview, I provide a more detailed plan for the lesson. It is my intention that these plans will provided enough guidance for interested readers to be able to try implementing these lessons in their own classes.

Lesson: Linear Functions, Living Wage, and Student Tuition

Lesson intention. This lesson is a variation of Rico Gutstein's *Living Wage* which uses linear functions to examine the economic challenges that many students and families face (Gutstein, 2005). For this first social justice lesson, I did not want to risk tokenizing or essentializing my students' experiences, so I planned play it safe with a lesson that connects to their identity of being a student. I chose a lesson that discusses a living wage, linear functions, and the fact that the faculty association reports that students have to work 3.5 times more than students in 1985 in order to pay off tuition.

Lesson overview. This lesson is based on article from the California Faculty Association , *Equity interrupted: How California Is Cheating Its Future.* The social justice focus is on the challenge of paying for a college education and concerns about minimum wage. The mathematical focus is on modeling with linear functions while reviewing topics such as rate of change, y-intercepts, and x-intercepts. The lesson proceeds as follows:

- Students read *Equity interrupted: How California Is Cheating Its Future*
- Student receive a guided handout, Class Activity: Work or Study #StudentProblems (see appendix D).
- The instructor provides a prompt and some lecture to set up the context and work through initial problems using linear functions to model the data in the article, closely analyzing the effects on different rates of changes and how that effects the x and y intercepts
- Students work in groups of 3-4 (also guided by the handout) to set up independent and dependent variables and translating a story/scenario to a mathematical equation.
- After the lesson, students personally reflect after reading *Equity Interrupted: How California Is Cheating Its Future.*

Lesson details. I begin by sharing the following statement from the reading:

> In 1985, CSU students had to work 199 hours at minimum wage to pay tuition and fees for an academic year at the CSU. In 2015, students had to work 682 hours at a minimum wage job to cover those costs (California Faculty Association, 2017).

Then I supply students with some extra facts:

- That's almost 3.5 times the work students in 1985 had to put in just to cover tuition and fees.
- Not surprisingly, too many CSU students work more than is healthy for their academic success. According to CSU system-wide data, three out of four CSU students today work more than 20 hours per week (California Faculty Association, 2017).

I make the following disclaimer:

> Before I ask questions, I need to make a point that today we will have the opportunity to share our stories within your groups. You will find out that some of you work and some of you don't have to work. There is absolutely no shame in either situation. My goal is for us to mathematically make sense of the topic we will be discussing today.

I then share my experience as a student …

Next, I ask students to answer and discuss the following questions amongst their groups: "What are some of your experiences while working and going to school? If you do work, what resources do you use?" The purpose of this question is to help students learn from on campus resources and listen to each other's stories, thus hopefully building rapport. While students discuss amongst their groups, I plan to walk around the room to help facilitate a group discussion, and I hope to hear some of my students' stories.

I distribute the handout, Class Activity: Work or Study #StudentProblems, and then make the following remarks:

> Is tuition a set price? How to we account for interest? When we have taken out loans? We will have more tools coming soon! We are going to have to make some simplified assumptions. Does a student graduate in four years?

In a guided example, I demonstrate setting up and comparing variables, asking for student input on the choice of variables and the scaling of the graph. For example:

> Let x= number of hours worked
>
> Let y= amount of money available to spend

We graph the green line (Figure 1) to represent the scenario in 1985, where I claim the breakeven point to be represented by the x-intercept, (199,0). I ask the class to discuss why this is the breakeven point?

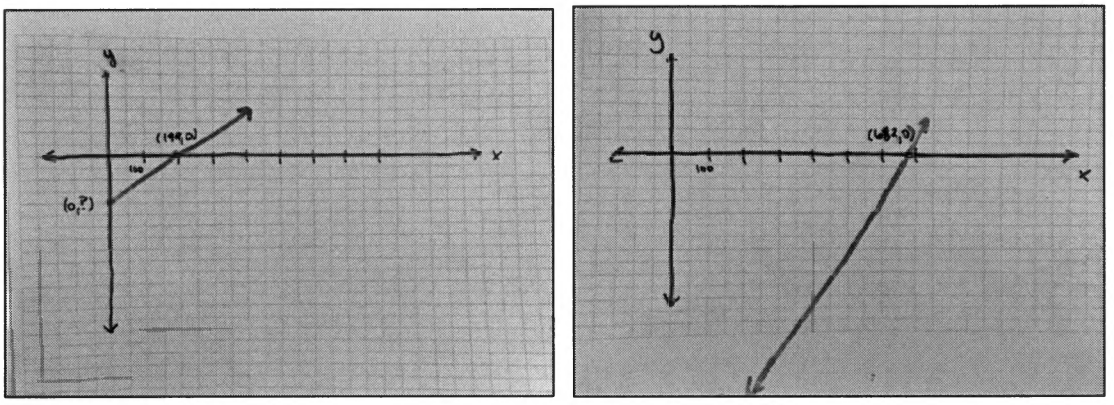


Figure 2. Graphs of 1985 (left) and 2015(right) of hours worked (x) against money available to spend (y).

I then graph the second scenario on a similar set of axes and ask students what are some implied facts that are reflected in the graphs of these two scenarios. Possible student responses include:

- We know that the minimum wage has gone up since 1985. So, the graphs with the higher minimum wage will be steeper.
- Increased tuition is represented by lower y-intercept.
- More hours worked to pay off college experiences is reflected by the change in x-intercepts.

During class, I encourage students to use the internet to fact check the material presented to them and to find their own data. Finally, we construct a graph using the minimum wage of 2015 and the number of hours, the break-even point from 1985, to show students how much tuition should have been in 2015 given those factors.

The lesson ends with students discussing the situation in their groups and using the graphs to explain whether or not they think the current situation is fair.

Follow up Assignments.

In order to further support students after this lesson, I required them as part of the homework assignment to create a profile on the SFSU website in order to receive alerts about scholarships. Along with this homework assignment, students had to read the article, "Equity Interrupted," and they had the option to break up the reading amongst their classmates who were in their group during that day of the lesson. Along with reading the article and respond to, "whose story resonated the most with you?" students were asked to take their own tuition and their hourly rate to calculate when they will break even for their costs. If students did not work, I encouraged them to use the minimum wage rate of San Francisco at the time of the study.

In addition to this homework assignment, students were encouraged through an optional homework assignment at the end of the course to write a letter to their senator voicing their concerns using the mathematics they learned from this lesson.

Lesson 2. Composition of Functions: Misrepresentation

Lesson intention

The second lesson that I planned to implement in my SJP section provided both a shared experience to develop students intuitive and understanding of function composition and an application designed to engage students' critical consciousness. In the first part of the lesson, I wanted to make the topic of function composition tangible, so students could have access to concrete examples before getting to the abstract. In the second part of the lesson, I introduced students to the formal mathematical notation, connecting the lecture to the game they had played. The two parts of the lesson were designed to develop students' access to dominant mathematics.

In addition to make an abstract concept more concrete, I also wanted it to have the potential to make it personal and to engage students' identities and narrative. I wanted students to develop a relationship with the material they were studying and to be able to redefine the topic itself. For this, I posed the question to my SJP section: "How do you experience composition of functions?"

The application focused on using counter stories to challenge the notion of misrepresentation. There are many forms of misrepresentation in society for people who have been marginalized by their sexuality, gender, age, race, ethnicity, or other identity markers. My goal was to allow students to have the opportunity to re-write a narrative in a mathematical setting, specifically through composition of functions. In the homework, I encouraged student to let their imaginations to go wild as they created create their own conceptions of composition of functions.

I also provided students the optional assignment of creating their own counter stories on the homework. My experience of power of creating counter stories comes from an activity during my undergraduate education called *papelito guardados* in Miguel Lopez' class, Educational Issues and the Latino Community. I do not take this activity lightly for

it required a level of trust between professor and student, and I had already known the professor for over a year. Therefore, the activity that I implemented in my SJP section is one that I would not have done during first third of the semester. Because this element of trust is needed between professor and student, I made this final portion of the lesson voluntary for students to complete.

Lesson overview

This lesson is composed of three parts. Part I is a game to expose student to the composition of functions. Teams of three students evaluate the composition of functions for different values and experience how to compose functions. The second part of the activity is a lecture to introduce formal mathematical notation for composition of functions, connecting the examples to the functions that students saw in the game. The third part of the activity introduces two functions from a social science context that show how mappings can shape narratives and identity. In this activity, students are encouraged to define an alternate function for the "outside function" in the composition and observe that changes the narrative of the composite function.

Lesson details.

Part I: The Game. Students participate the "Composition of Functions Relay." In groups of 3, with each student assigned their own function (Better Lessons, 2017). There are 4 rounds. In the first three rounds, player number 1 is given an input value (first -1, then 2, and then 0) for their function. The output of the first player's function becomes the input to the second player's function. The output of the second player's function is passed to the third player to input into the final function. In the 4th round, the players compose the functions in the opposite order. Player three receives the input value zero, passes the output to player to as an input for their function. The output is passed to player one to input into their function. This last round is done to illustrate that composition of functions is not always commutative.

After the four rounds, we discuss how this game is a kinesthetic experience of the composition of functions.

Part II. Formal introduction to notation. For this lecture, students may leave their groups in order to get a better view of the white board. I will discuss the following definitions and examples:

Composition of two functions.

If f and g are functions

$f \circ g$ is another function called the composition of f and g and is defined:

$$(f \circ g)(x) = f(g(x))$$

Notice that the evaluation of composition of functions is counterintuitive to the way we read English or Spanish, which is read from left to right.

Another way to think about composition of functions is through the visual representation of the mappings.

Example 1. Let $f(x) = x^2$ and $g(x) = x - 3$. Find expressions for $(f \circ g)(x)$and $(g \circ f)(x)$.

The big takeaway from this example is that composition of functions is not commutative. Thus, it is important for students to identify which function is occurring first.

Example 2. Let $f(x) = \sqrt{x}$ and $g(x) = x^2 + 1$. Find $(f \circ g)(x)$ and $(g \circ f)(x)$

Part III: Application. Opening question for the students is "How do we experience composition of functions?"

I begin by share an example through my own story: Growing up as a labeled "at risk" kid, I was pre-dispositioned to have a particular future that was not too hopeful. For this composition of functions, I want to stress to students that this is the message that I have received experienced through media and the news. A function, z , maps each person to their zip code at birth. Then the function n, maps each zip code to the crime rate for that zip code. I will tell the class that I do not like this mapping of myself, even though it is something that I grew up hearing.

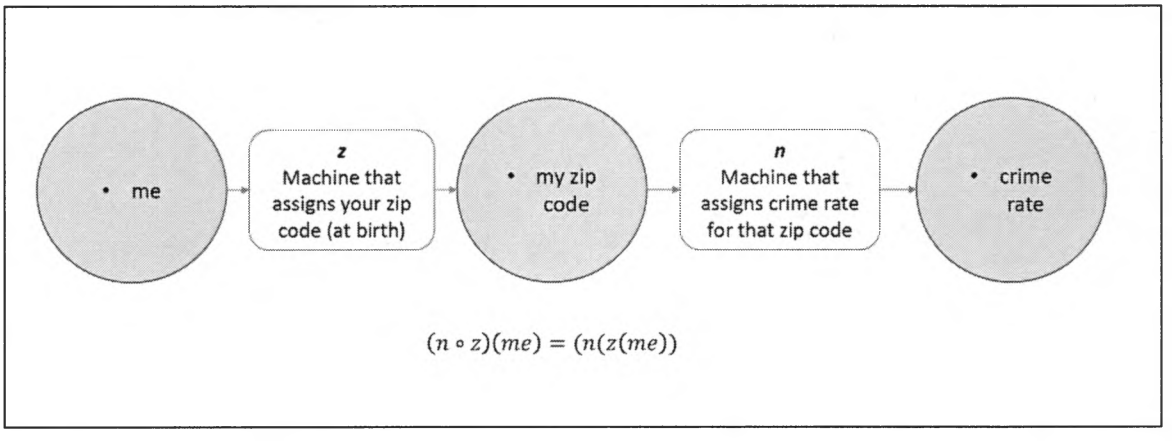


Figure 3. How I, the instructor, experienced C.O.F. growing up.

Next, I challenge the class to come up with maps that positively frames where I grew up using less deficit-oriented functions that highlight shed light on the positive features of parts city that never makes the news. While the z function might stay the same, the second function could be a function $\boldsymbol{j}$, that maps a zip code to the average number of jobs a given household holds or a function, $\boldsymbol{l}$, that maps a zip code to the average number of languages a given household speaks.

Lastly, the exit tickets will be distributed. The homework assignment asks them to use their imaginations to create their own diagram or example that of functions, which are available in the appendix B.

Lesson 3: Unit Circle and Radian Measure: Building from a Shared Experience

Lesson intention

The goal to this lesson is to better prepare students before they are exposed to the unit circle. Based on previous experiences with teaching this pre-calculus course and the experience of that of my colleagues, the trigonometry section is where we lose a lot of our students. That portion of the semester is one that can be broken up into a whole other course. Hence, the pace of the class primarily benefits those who have been exposed to the concepts of trigonometry in their past.

At this point in the semester, time was definitely a factor in the way that I designed the lesson. We were approaching the end of the semester, and the days I took to cover certain material was critical. I had the consideration of creating a lesson that is similar to that from the University of Hawaii where they have a lesson on star navigation and the unit circle. Given the complexity of the lesson plan itself, I did not feel like I had adequate time to make sure that my students would fully understand the mathematics. More importantly, that lesson was implemented in Hawaii as a way to connect with students from that region. Even though I knew the chances were smaller for my students to relate to that lesson, I wanted to be mindful of implementing work for the concern of treating students like they are a mere representation of their culture.

So, for this lesson I decided to stick more with the dominant mathematics. In other words, I wanted to make sure that students had access to the concept of the unit circle. In order to achieve this, I wanted to make sure that I provided an experience for students to gain exposure to topics that we as instructors assume our students already understand. Additionally, I wanted students to have more of a connection intellectually with the concept of the special right triangles 30-60-90 and the 45-45-90. This idea was influenced by Robert Moses notion of shared experience (Moses, 1989). I wanted students to literally play with

the special triangles before using them for the introduction of the unit circle the following day.

Lesson overview

This lesson focuses on special triangles prior to our introduction of the unit circle. Students work with physical right triangles, the half-equilateral (30-60-90) and the isosceles right triangle/half-square (45-45-90), to figure out how these triangles fit into the unit circle. They are also make sense of the relationships between the sides and the hypotenuse on each of these triangles so that they can apply these to the values of sine and cosine found on the unit circle.

Lesson details

In order to make sure that students have some common starting points, the first ten minutes are set aside for reviewing three concepts that are taught in pre-requisite math courses. These three facts are be presented as prior knowledge, without justification, but they are open for student comment and discussion:

1. The sum of the angles in any triangle is 180 degrees.
2. The Pythagorean Theorem: In a right triangle, the sum of the squares of the two legs (shorter sides) is equal to the square of the hypotenuse (the longest side).

Next, students choose their own groups of up to 4 members. Allow student to select their own groups is intended to assure that they feel comfortable making mistakes in front of these group members. Each student (or each group) receives at least three blue 30-60-90 triangle and at least two pink 45-45-90 triangle, but they are only told that each triangle has a 90-degree angle and that the hypotenuse is 1. They need to work together to figure out the measure of the two acute angles and lengths of the legs and justify their reasoning. This exploration of the right triangles is what entails for the student shared experience.

During this portion of the lesson, the instructor facilitates group discussions, listening for different strategies and connections that students can share during the whole class discussion. Strategies that may emerge include for finding the angles and sides of the pink triangles include:

- the two acute angles of the pink triangle are congruent,
- two pink triangles make a perfect square when they are connected along their hypotenuse, so the acute angles the pink triangles are half of a 90-degree angle,
- the legs of the pink triangle are congruent,
- the area of the square formed by four pink triangles is 1, so the area of two pink triangle is $\frac{1}{2}$, so the length of a leg is $\sqrt{\frac{1}{2}}$ $\sqrt{\frac{1}{2}}$ or $\frac{\sqrt{2}}{2}$.

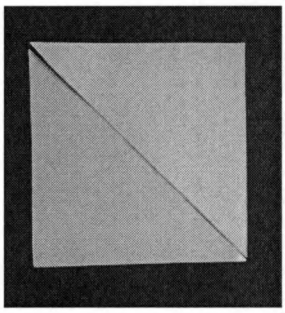


Figure 4. Two half square triangles with hypotenuse 1, forming a full square.

Strategies that may emerge include for finding the angles and sides of the blue triangles include:

- three copies of the smallest angle of each blue triangle form a 90-degree angle, implying that the smallest angle of that blue triangle is 30 degrees.
- two blue triangles placed with longer legs together and right angles touching form an equilateral triangle with 60-degree angles.

- the hypotenuse of the remaining triangle can be used as a ruler to ensure that the sides of the equilateral are indeed 1, so the short leg is $\frac{1}{2}$.
- students can use the Pythagorean theorem to find the length of the longer leg of the blue triangles.

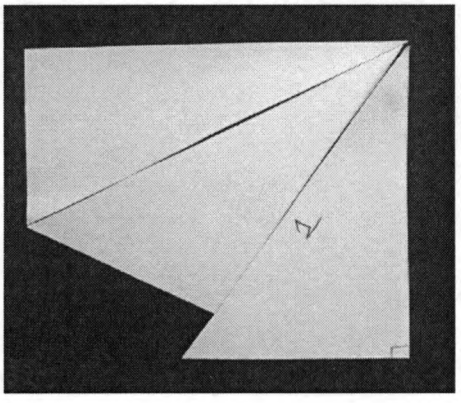


Figure 5. Three half -equilateral triangles used to make a 90-degree angle.

While students facilitating this part of the lesson, I will also remind students to engage with each other's ideas and to use body language that is inclusive to all members of their group. Towards the end of the lesson, students I will select members from certain groups to share their findings to the rest of the class. As I do this, I hope to encourage different ways of approaching to a discovery as it pertains to this lesson. After gaining familiarity with these objects, the two triangles, I plan to explicitly talk about them in the next lecture where I will be introducing the right triangle.

Chapter 5

Results

This chapter presents the results pertaining to the second and third research questions.

ii. How did students' experiences in the three SJ lessons affect their perception of membership, support and relevance in their math class?

iii. How did the additional time spent on the three lessons in the social justice pedagogy class affect the students' learning of mathematics content?

First, I present the results from the initial survey of pre-calculus students, showing their impressions of how integrating connections between the mathematical content and their life experiences would affect their sense of belonging to pre-calculus. Next, I share the results from the exit surveys after each lesson, comparing the experience of the students in the social justice section with the standard section. Third, I analyze examples of the student work on written assignments following the social justice lessons. Finally, I compare the final grades and performance on a common cumulative assessment in the two sections.

In an on-line survey at the start of the semester, students from all eleven sections of pre-calculus were asked to answer the following question:

Do you believe you would have a greater sense of belonging to Math 199 if the content of the math problems you were asked to solve were closely related to your everyday life?

For the sake of simplicity, I am going to refer to this question as the "sense of belonging and relevancy" question in the following figures. Of the 131 responses to this question on the survey, sixty-six percent responded that they believed or strongly believed that their sense of belonging would increase if the mathematics they engaged in was relevant to their lives as shown in figure 6. Breaking down these responses by gender did not show any difference between male or female students opinions. Similarly, when

the responses were separated by first, second, or third generation college students, the proportion of believe or strongly believe responses did not change.

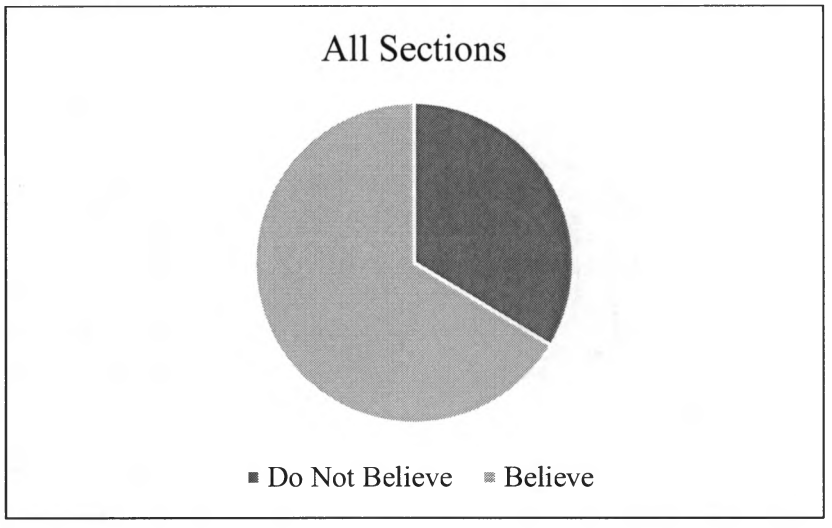


Figure 6. Students' thoughts on CRP from all sections.

However, the students from the two sections involved in the comparative study felt even more strongly about the importance of making connections between the math and their lives.

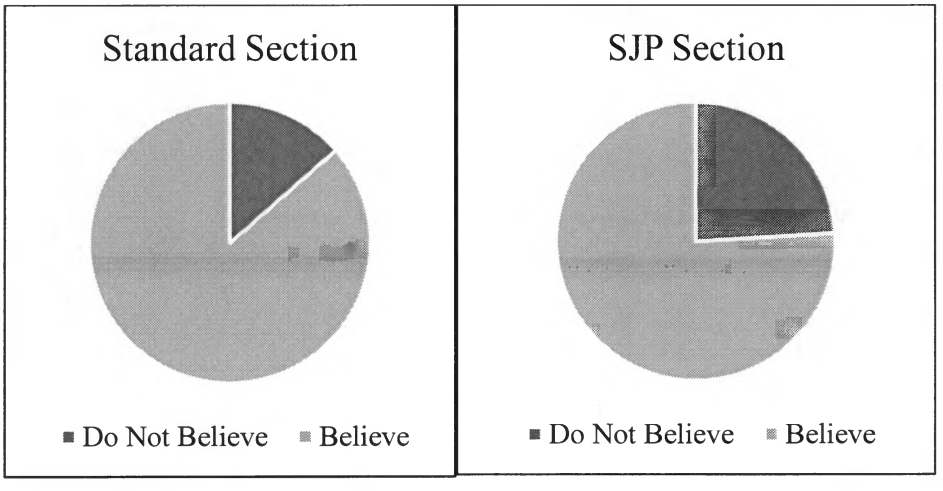


Figure 7. Students' thoughts on CRP from Standard and SJP section.

In figure 7, eighty-six percent of students agreed that sense of belonging to the class would increase if problems were relevant, while 76 % of students from the SJP section believed that relevancy would increase sense of belonging. These numbers suggest that culturally relevant lesson plans may increase students' experiences.

In the SJP course, 25 students responded to the question posed above, where 19 agreed to believe that relevant mathematical content would increase a sense of belonging. Whereas for the Standard section, 22 students responded in which 19 believed that relevant math content would increase their sense of belonging.

Exit Ticket: Surveys

In order to measure the three factors of students' sense of support, student's sense of membership, and students finding the curriculum relevant, I averaged the score of each students' responses to a particular set of questions from a four-point likert scale. Details can be found in chapter 3.

Exit Ticket Survey for Lesson on Linear Functions

For the lesson on linear functions, twenty-one of Emilio's students from the Standard section were surveyed, while thirty-one of my students from the SJP section were surveyed.

Table 6.

Percentage of students who agreed to have felt a sense of support, sense of membership, and found the lesson relevant after the linear functions lesson.

Section	Sense of support	Sense of membership	Lesson relevance
SJP Section n= 31	39 %	39%	39%

Standard Section n=22	33%	33%	35%

Overall, the equity-oriented lesson implemented in the SJP section provided a slightly better experience for students in the SJP section. Students in the SJP section felt more supported, felt like members of the class, and found the lesson relevant by five to six percent more in comparison to the Standard section.

Table 7.

Percentage of students who agreed to have felt a sense of support, a sense of membership, and found the lesson relevant after C.O.F. lesson.

Section	Sense of Support	Sense of Membership	Lesson Relevancy
SJP section n=22	68%	64%	50%
Standard Section n=20	60%	65%	35%

Overall, the equity- oriented lesson implemented in the SJP section provided a slightly better experience for students in the SJP section except for feeling members of the classroom. Nonetheless, there is still a 25% increase in sense of membership in the SJP section from the linear functions lesson to the composition of function lesson.

Table 8

Percentage of students who agreed to have felt a sense of support, a sense of membership, and found the lesson relevant after introduction of the unit circle.

Section	Sense of Support	Sense of Membership	Lesson Relevancy
SJP section n=21	67%	67%	62%
Standard Section n=17	41%	41%	24%

Overall, the equity- oriented lesson implemented in the SJP section provided a much better experience for students in the SJP section. Of all the lessons, the unit circle had the greatest differences between classes.

Comparing Classes: A Closer Look

As noted in the previous tables, when it comes to comparing both sections in respect to the given lesson, differences between feeling supported, feeling like a member of the class, and finding the lesson relevant have some disparities when looking at one particular lesson for both sections. But if we look at each section and study how they felt supported over time in comparison to the other class, we can also see another difference between classes. We will take a closer look with the following figures. We hope to see how each factor fluctuated over time of the three lessons between classes. It is important to note that these topics (Linear Functions, C.O.F, and Unit Circle) were implemented roughly three weeks apart.

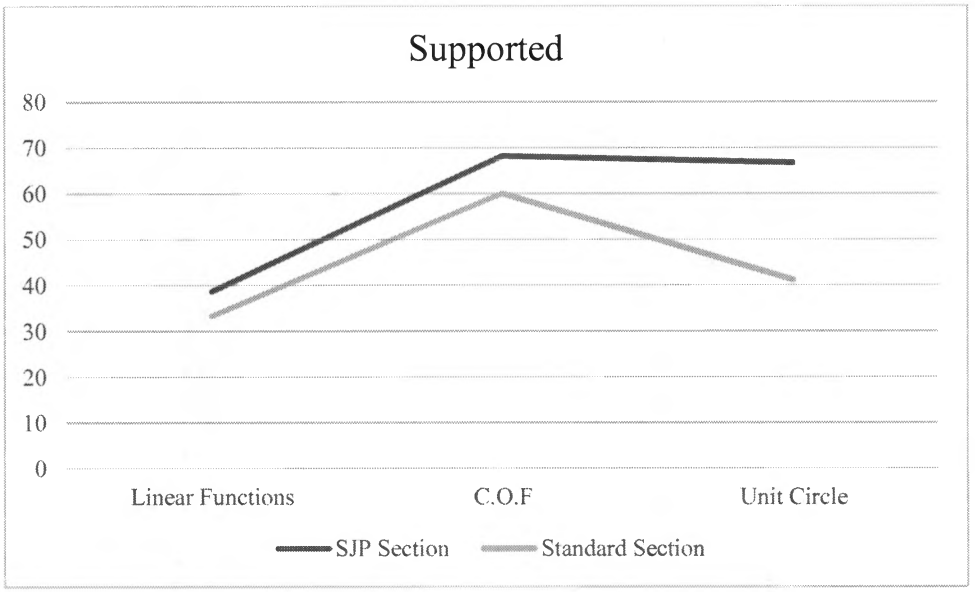


Figure 8. Percentage of students who felt a sense of support over the three lessons topics in both sections.

From Figure 8, students in the SJP section overall felt a greater sense of support in comparison to the Standard section. Overall students felt the most supported in the SJP section during the C.O.F. lesson.

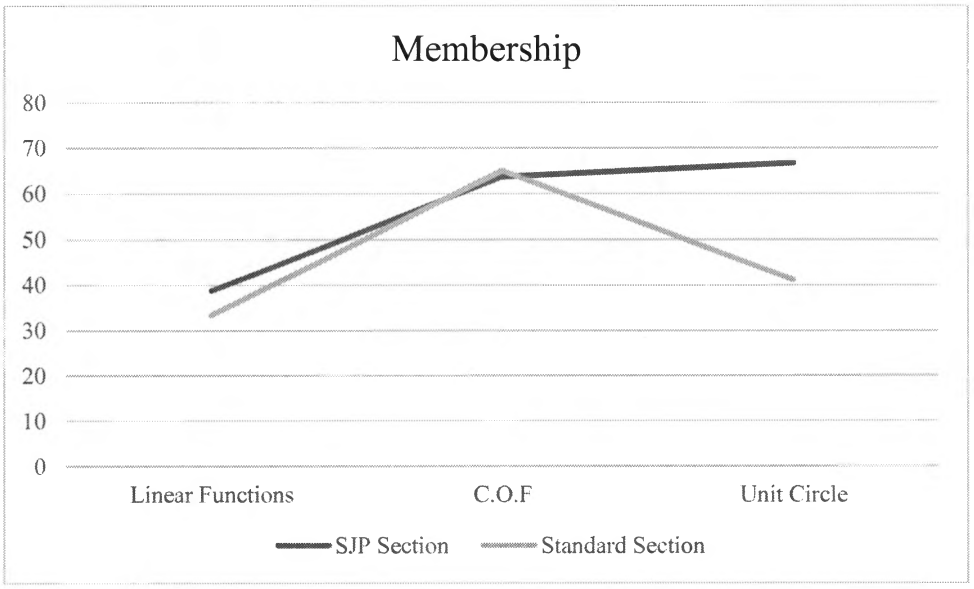


Figure 9. Percentage of students who felt a sense of membership over the three lesson topics in both sections.

Overall, students from the SJP section felt more supported after the designated lessons except after the C.O.F lesson implementation.

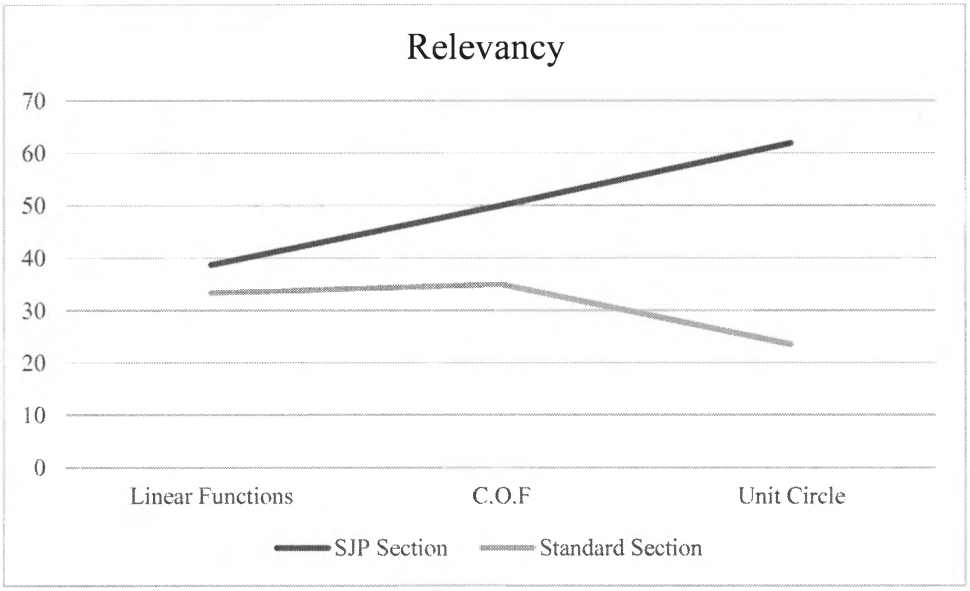


Figure 10. Percentage of students who agreed to have found the lesson relevant.

When it comes to relevancy or finding the lesson relevant to students' lives, this is the area in which I expected the most of a difference between sections. Overall students in the SJP section found the lessons relevant to their lives, but when it comes to the results from the unit circle, I am left quite confused. Recall that the unit circle was more of a lesson that aimed to attend to the dominant mathematics, thus I was not making any deliberate effort to connect the content to my students' lives. Yet, according to these results the students from the SJP section found the unit circle lesson the most relevant. This leaves me questioning what my conceptual understanding of relevant means and that of my students. Even though this lesson may have not been relevant to their outside world, it may have been relevant to their success or survival of the class.

Exit Tickets: Free Responses

At the end of each of the three lessons (linear functions, composition of functions and unit circle), students were given an exit ticket with the same question for both the Standard section and the Social Justice Pedagogy section. Students had to respond to the following prompt:

Briefly describe what you think were the important or big takeaways from today's class.

This question was not designed to answer a specific mathematical question because I wanted to see what students walked away with the most. Throughout each set of responses, I was generally looking for 1. Any identification of finding the lesson **relevant** or personal to student's lives or their world outside of class 2. **Mathematical Notation**/Equations or Formulas 3. **Mathematical Explanations** that showed further understanding of the concept being studied.

There are some responses that counted for more than one category. For example, there were students who expressed a sense of relevancy to the topic being studied and demonstrated further understanding of the topic through mathematical explanation. Student examples of these responses can be found in chapter 3.

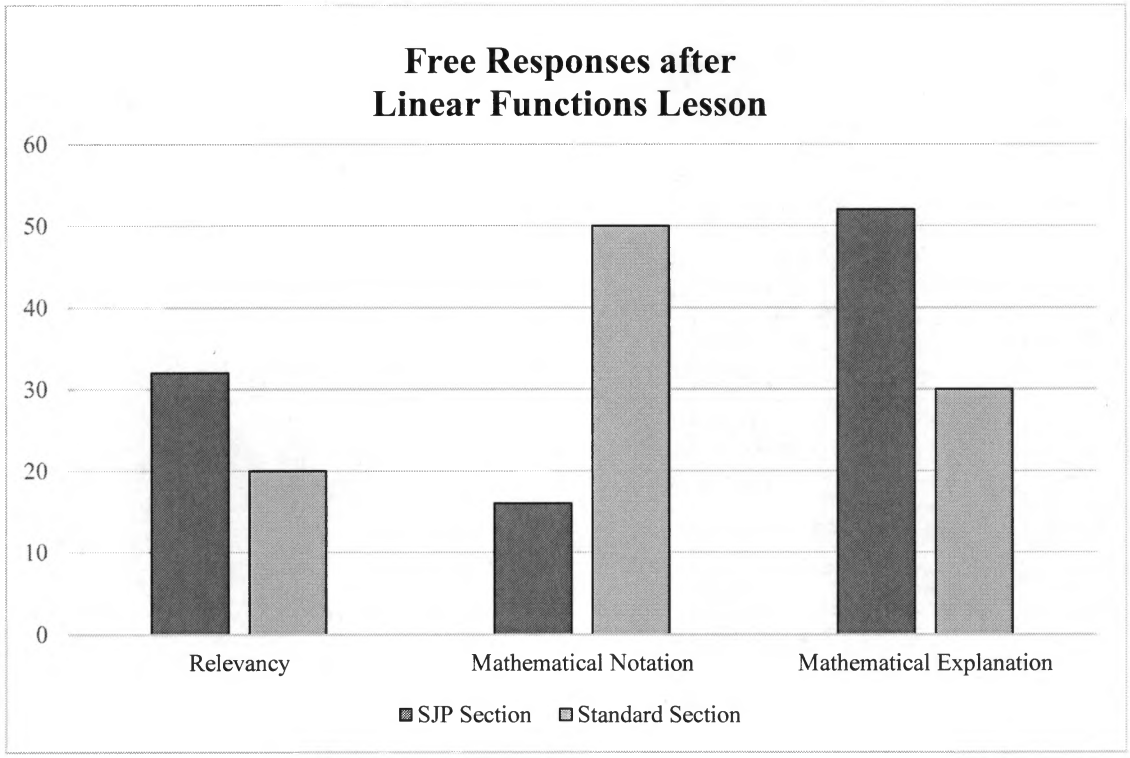


Figure 11. Free response breakdown linear functions lesson by percentages.

As shown in figure 11, in the SJP section the percentages of free responses are in respect to 32 student responses, where those responses fit into the three categories. Of those three categories, 25 responses were considered. Because of the different sample sizes in sections, the data was presented as percentages. The same coding was applied to the Standard class where of the 21 student responses, there were 10 that appeared to fit in the three categories.

Table 9

Tally of free responses from the exit ticket after linear functions lesson.

	Relevancy	Mathematical Notation	Mathematical Explanation
SJP section	8	4	13

Standard section	2	5	3

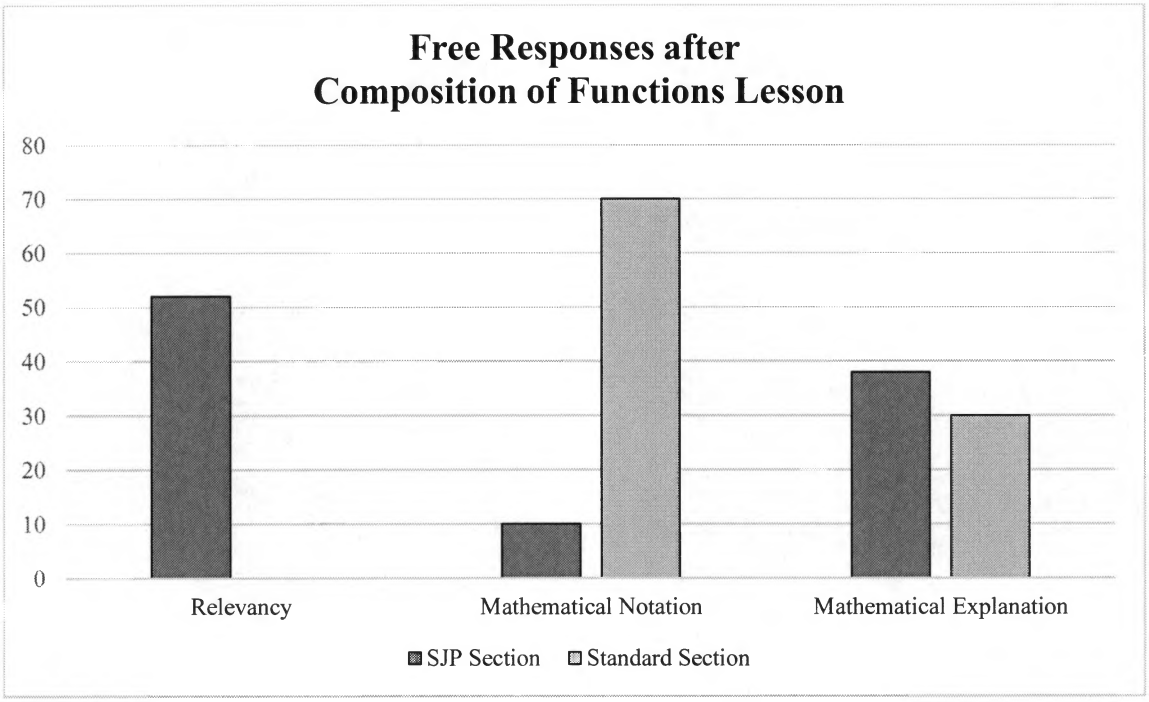


Figure 12. Free response breakdown after lesson of C.O.F. by percentages.

For this lesson, 21 student responses were coded from the SJP section, while 19 student responses were coded from the Standard section. Figure 15 shows the percentage breakdown of the types of free responses after Lesson 2 (composition of functions) in both sections.

Table 8

Tally of free responses after lesson two.

	Relevancy	Mathematical Notation	Mathematical Explanation
SJP section	11	2	8

Standard section	0	7	3

For the lesson of composition of functions, there was no intentional moment made to make an application problem of C.O.F. for the sake of time in the Standard Section. Therefore, those remarks were not made in the free responses by students.

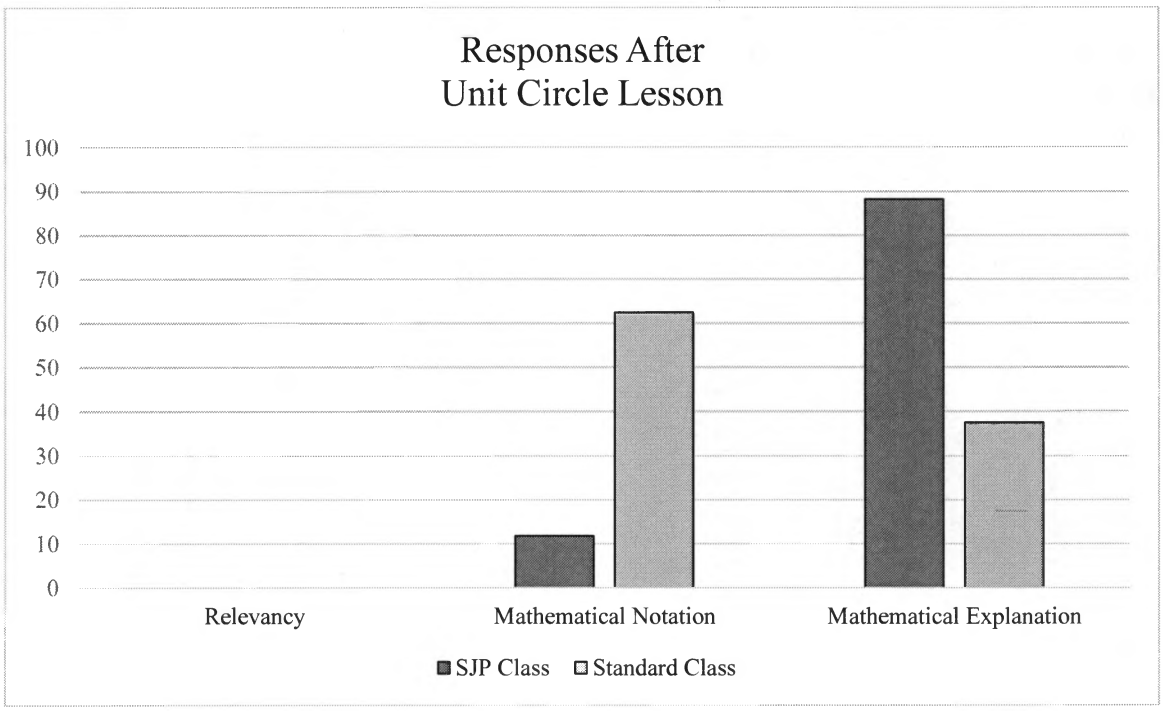


Figure 13. The Percentage of Student free-response after unit circle lesson.

For this lesson 23 student responses were coded from the SJP section while 17 student responses were coded from the Standard section. Roughly twelve percent of student from the SJP section provided mathematical notation, while 88% of student responses provided a mathematical explanation.

Table 9

Breakdown of the tally of student free-response after unit circle lesson.

	Relevancy	Mathematical Notation	Mathematical Explanation
SJP section	0	2	15
Standard section	0	5	3

Amongst all three lesson topics, the SJP section provided more mathematical explanations, while the Standard section provided more responses with mathematical notations. This may indicate that the SJP section provided more levels of understanding after the designed lesson plans. Along with mathematical explanations, the SJP section responded with more relevant like responses on the exit tickets indicating that the relevancy of the math problems was one of the important takeaways of the class lecture/activity.

Homework Assignments

For the EOP lessons on topics of the Linear Functions and Composition of Functions, the Social Justice Pedagogy class was assigned a specific assignment that can be found in the appendix.

Homework After EOP Lesson: Living Wage and Tuition Prices

For this assignment, students were asked to read "Equity Interrupted," and they were asked to reply to the following prompts:

Part I: Following what we did today, look up and calculate your costs and use which ever minimum wage applies for you. For those of you who do not need to work to pay off costs, use San Francisco's 13-dollar minimum wage (which was passed 7/1/16).

Part II

1. How would you define a *living* wage? There is a lot of discussion in regard to making CA's minimum wage $15 dollars per hour. What are your thoughts?

2. Given your costs, do you think minimum wage should go up? Down? Should the cost of tuition go up? Or down? What seems fair to you?

3. What are your thoughts on the article? Whose story resonated with you the most? Is there any data that you are questionable about or that you would like to further explore?

Student Responses

For this assignment, students had a variety of responses ranging from different levels of engagement both critically and mathematically. The following homework responses presented were either classified as either being strong in the dominant and critical mathematics, more critical than dominant, more dominant than critical, and lastly lacked both critical and dominant mathematics.

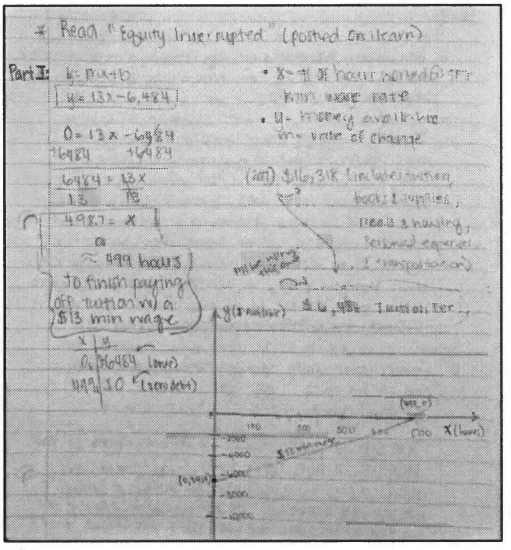


Figure 14. Homework response to part I. Student from S.J.P. Class responds to part one of the homework assignment.

This assignment is one of 36 student responses and of those 36 responses, twenty of those showed strengths in both the dominant mathematics through mathematical proficiency and also illustrated some to high levels of critical thought in respect to the topic of a living wage and student tuition.

Their Voice

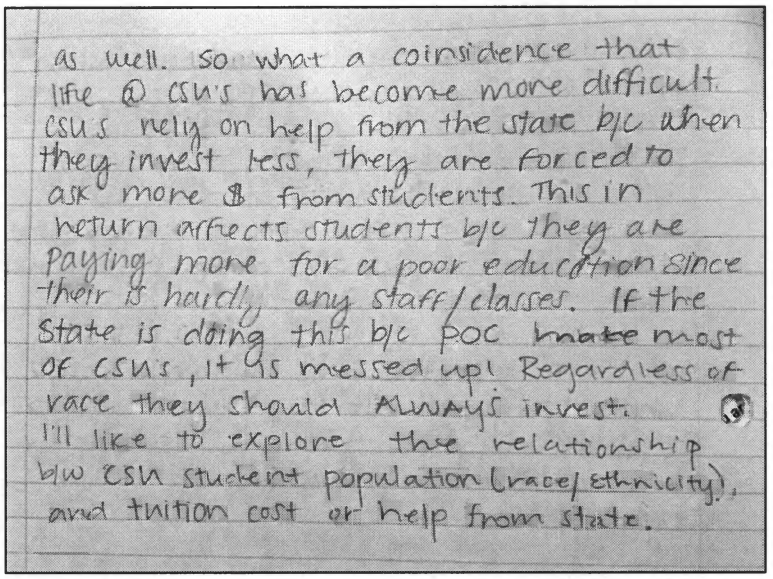
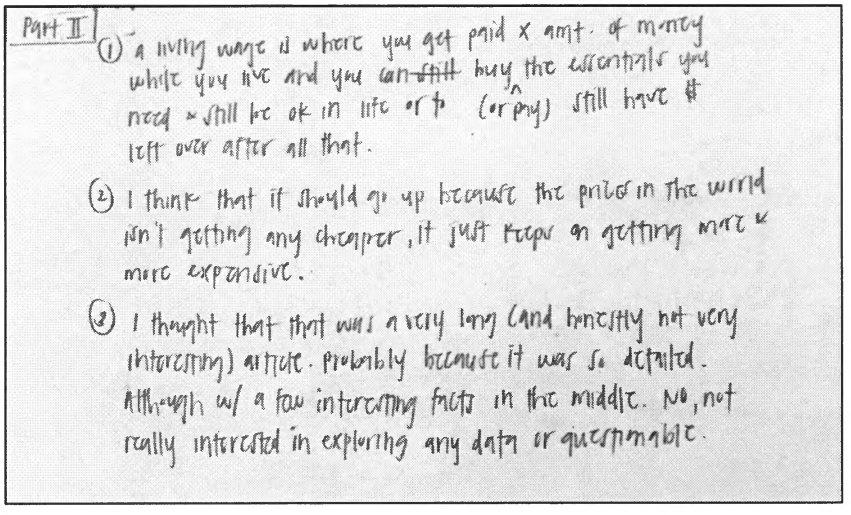

as well. So what a coinsidence that life @ CSU's has become more difficult. CSU's rely on help from the state b/c when they invest less, they are forced to ask more $ from students. This in return affects students b/c they are paying more for a poor education since their is hardly any staff/classes. If the State is doing this b/c POC make most of CSU's, it is messed up! Regardless of race they should ALWAYS invest. I'll like to explore the relationship b/w CSU student population (race/ethnicity), and tuition cost or help from state.

Figure 15. Expressing Their Voice in Part II of the Homework.

A student from the SJP section responds to part two of the homework assignment in figure 15. "Regardless of race they should always invest [in their students]." Student responses like those of Figure 21, illustrated that some students really utilized this space/opportunity in the homework assignment to voice their opinions. This one like many others illustrated a level of not only intellectual thought and stance, but they also expressed emotion. This student response is the same one from figure 14.

Pushback


Part II

(1) a living wage is where you get paid x amt. of money while you live and you can ~~still~~ buy the essentials you need & still be ok in life or to (or pay) still have $ left over after all that.

(2) I think that it should go up because the prices in the world isn't getting any cheaper, it just keeps on getting more & more expensive.

(3) I thought that that was a very long (and honestly not very interesting) article. probably because it was so detailed. Although w/ a few interesting facts in the middle. No, not really interested in exploring any data or quesionable.

Figure 16. Pushback to critical mathematics.

With Figure 16, we can see some of the pushback to engaging in the homework from the SJP section when asked to answer part two of the homework assignment. This was one of 30 who expressed a conscious and direct level of disengagement from the assignment. Of the 36 homeworks that were turned in, this assignment was one of the five that showed little mathematical proficiency and little critical thought.

Building Rapport

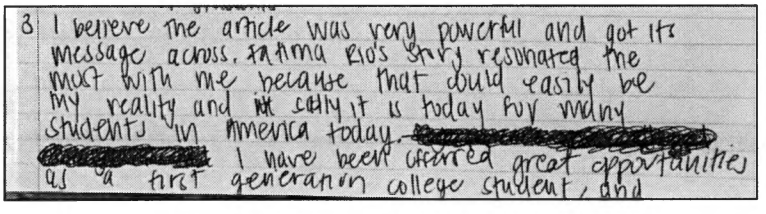

3 I believe the article was very powerful and got its message across. Fatima Rio's story resonated the most with me because that could easily be my reality and sadly it is today for many students in America today. [redacted] I have been offered great opportunities as a first generation college student, and

Figure 17. Building rapport through homework.

Responses like the one in Figure 17, gave insight to the lives of the students in the classroom. This by default, helped build rapport with the students over time. As the instructor of the course, this allowed me to find better ways to further support my

students, whether that was by introducing them to faculty members or other school organizations. This was also a student response who fell under the first category showing fairly high levels of critical and dominant mathematics.

Sympathy

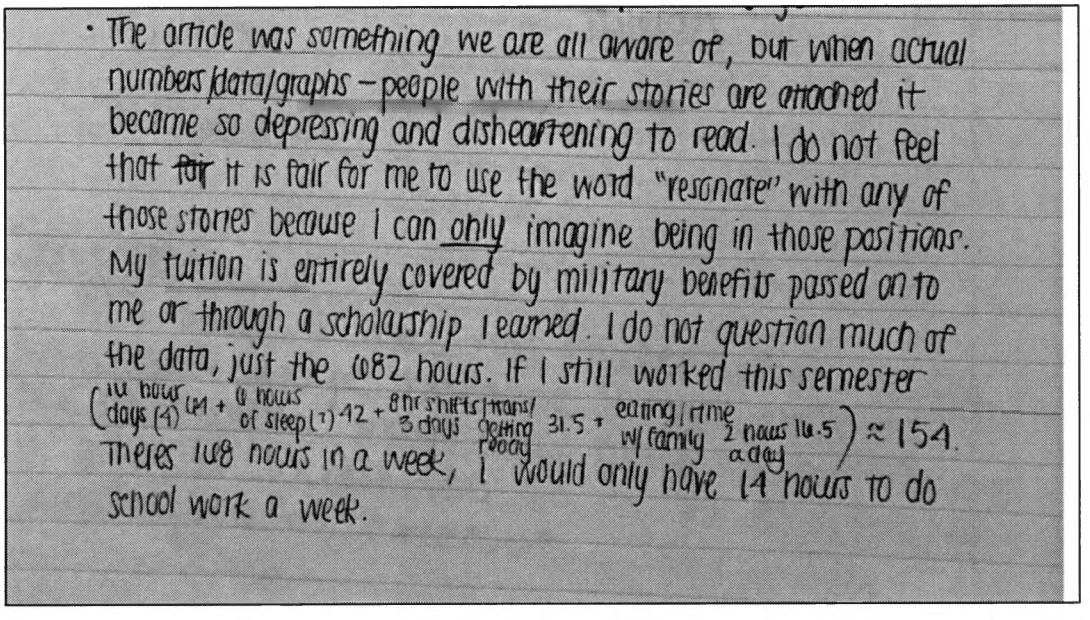

• The article was something we are all aware of, but when actual numbers/data/graphs – people with their stories are attached it became so depressing and disheartening to read. I do not feel that ~~fair~~ it is fair for me to use the word "resonate" with any of those stories because I can only imagine being in those positions. My tuition is entirely covered by military benefits passed on to me or through a scholarship I earned. I do not question much of the data, just the 1082 hours. If I still worked this semester (40 hours days (4) 160 + 6 hours of sleep (7) 42 + 8 hr shifts 3 days 24 + trans/getting ready 3 31.5 + eating/time w/family 2 hours a day 14.5) ≈ 154. Theres 168 hours in a week, I would only have 14 hours to do school work a week.

Figure 18. Sympathy through homework.

Responses like this one illustrates that the assignment served as an opportunity for students to tell a piece of their story. This student response, fell under the category that illustrated both high levels of critical and dominant mathematics.

Towards the end of the semester students were given the option to complete a homework assignment for extra credit. They were asked to write a letter to a senator using the mathematics to defend their stance on tuition prices. This assignment can be found in the appendix. From those who consented to the study, two students participated in the assignment.

Homework after EOP Lesson on COF: Misrepresentation

This homework assignment was assigned to the SJP section after the Composition of Functions and Misrepresentation lesson. There were three parts to this assignment. Students were given nearly a week to work on this because it was assigned right before spring break. For this assignment, students had to respond to the following prompt:

a. How would you describe compositions of functions to someone who has not taken algebra yet?

b. How can you reconstruct a composition of functions (or mappings) like we did in class that have **a positive outlook** rather than a negative fact?

Part 3: (Optional)

Counter-narratives:

Were there any times in life where you felt misrepresented?

Student Responses

Similar to homework one from linear functions, students' responses were coded based on their level of engagement in the dominant mathematics and the critical mathematics.

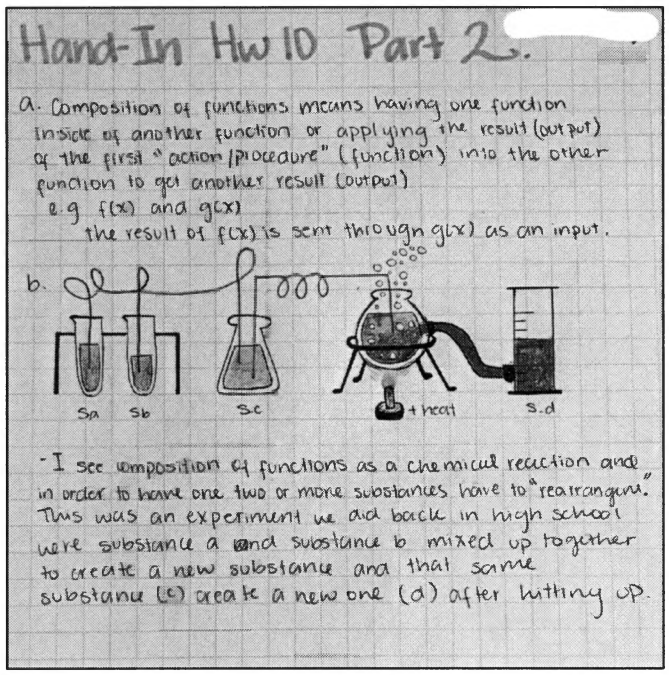
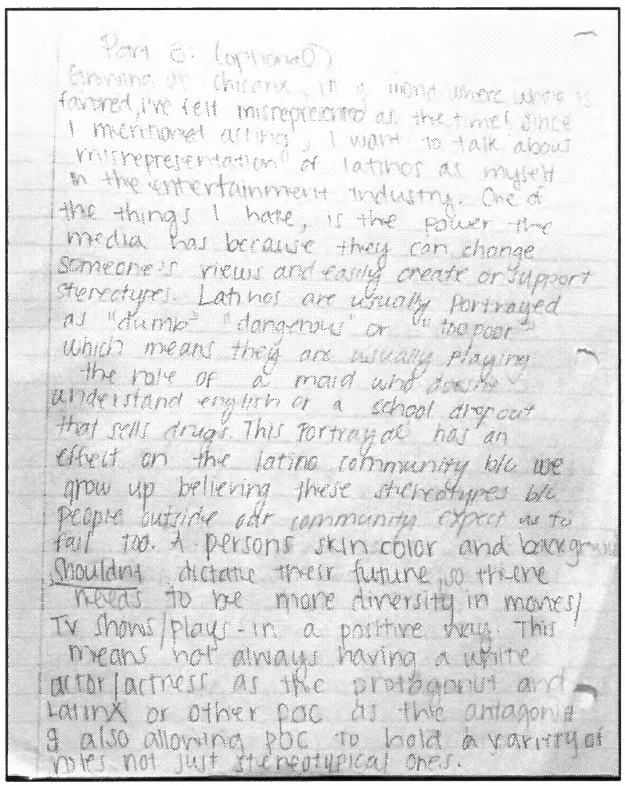


Figure 19. Chemistry Creativeness Response. Student from S.J.P. Class response to part two of the homework assignment two (Composition of Functions).

Responses like the one in Figure 19, was part of a small percentage of students who showed a strong level of engagement in the dominant mathematics. This student opted to answer part three of the assignment. When categorizing these homework responses, the notion of critical mathematics is taken very deliberatively. Of the 26 student assignments that were turned in, seven of them fell under this category of being more dominant than explicitly critical and personal.

Counter Narratives



Part C: (optional)
Growing up Chicanx, in a world where white is favored, I've felt misrepresented all the time! Since I mentioned acting, I want to talk about misrepresentation of latinos as myself in the entertainment industry. One of the things I hate, is the power the media has because they can change someone's views and easily create or support stereotypes. Latinos are usually portrayed as "dumb" "dangerous" or "too poor" which means they are usually playing the role of a maid who doesn't understand english or a school dropout that sells drugs. This portrayal has an effect on the latino community b/c we grow up believing these stereotypes b/c people outside our community expect us to fail too. A persons skin color and background shouldn't dictate their future, so there needs to be more diversity in movies/TV shows/plays - in a positive way. This means not always having a white actor/actress as the protagonist and Latinx or other POC as the antagonist also allowing POC to hold a variety of roles not just stereotypical ones.

Figure 20. Student from S.J.P. section responds with a critique of social order.

This student sample, is one that was much stronger on the critical mathematics rather than the dominant mathematics. The first part of this student's assignment had room for improvement for describing more accurately the concept of composition of functions. This response was one of the four of the homeworks that appeared to be more critical and personal as opposed to displaying strong levels of mathematical proficiency.

Nesting Dolls

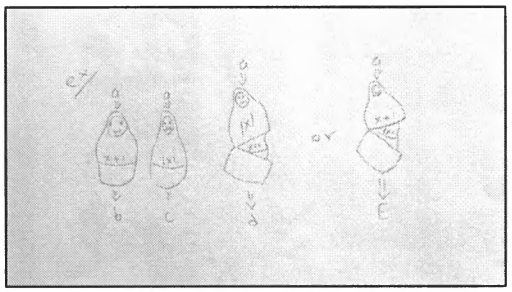


Figure 21. Traditional Example of Composition of Functions.

Similar to figure 20, this response was categorized as more dominant than critical since this student also opted from part three of the homework assignment. Similar to figure 19, this assignment fell under the category of showing a more stronger side in mathematical proficiency.

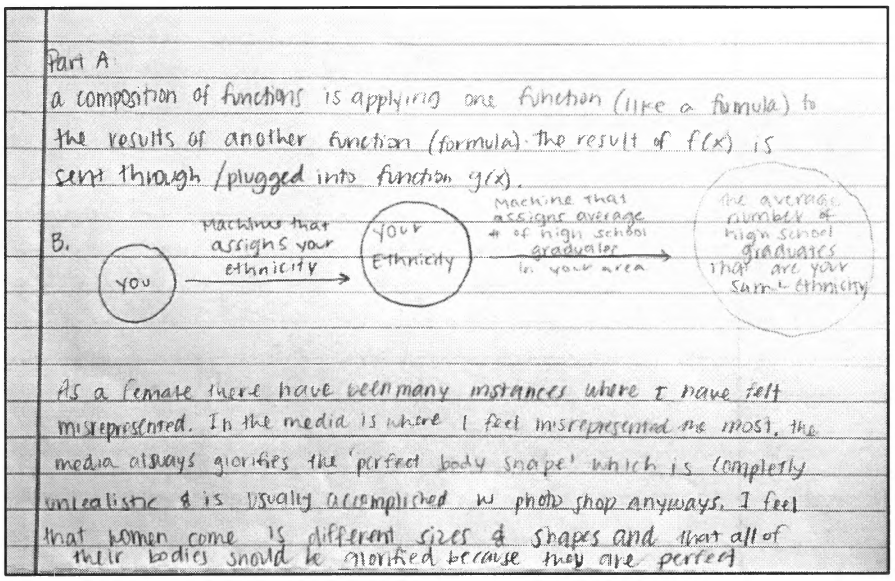


Figure 22. Dominant and critical homework response.

This assignment was classified as fairly strong in the dominant mathematical aspect except for one minor yet mathematical detail. Note the error in how they define the

second mapping, "machine that assigns average # of high school graduates in your area." This mapping should have been defined "machine that assigns average # of high school graduates from your ethnicity."

Along with demonstrating some levels of mathematical proficiency, this student engaged in the critical mathematics of the assignment. This student felt comfortable enough to share a piece of their story with the instructor. This was one of the four assignments that showed a strong sense of mathematical proficiency and a strong sense of personal connection.

MDTP Results

Math Diagnostics Test Project (MDTP) was an exam used to measure and assess students' knowledge of pre-calculus. This was an exam that was administered to all of the pre-calculus sections at SFSU during the last three weeks of the semester. At this point in the course there were students from both sections who had dropped the course.

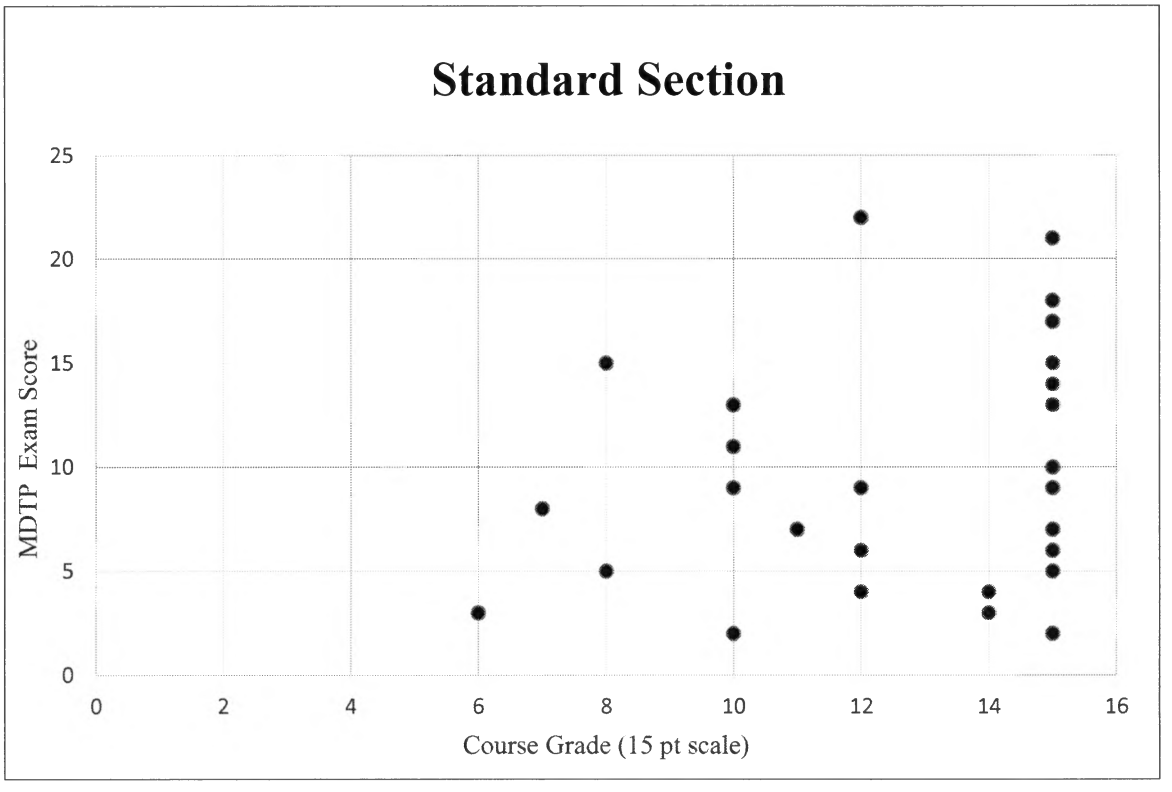


Figure 23. Standard class MDTP results and course grade.

For the Standard Class, the average raw score was 9.2 while the average course grade was 12.6. It is important to note that 32 students from the Standard Class took the exam. The purpose of these scatter plots was to also shed light of any possible inflation of both the grades Emilio assigned to his class and those that I assigned to my class.

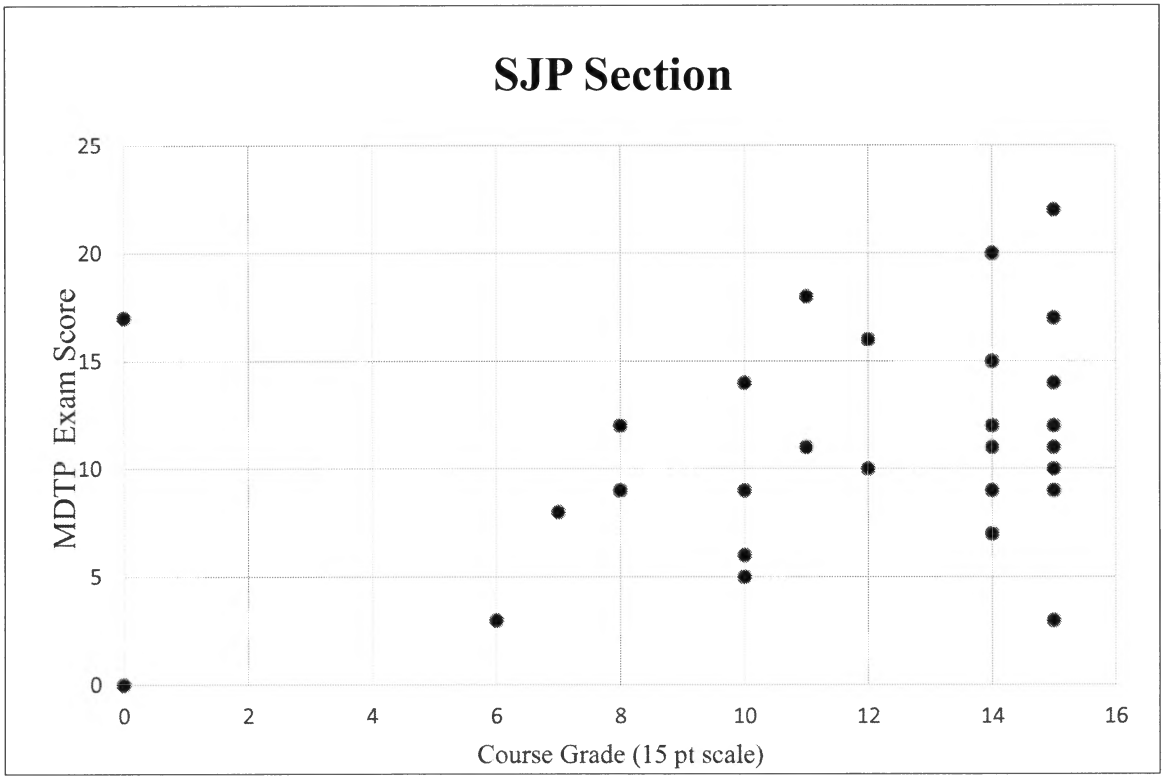


Figure 24. SJP class MDTP results and course grade.

For the SJP section, there was a slightly stronger correlation yet weak nonetheless. The average MTDP raw score for this section was a 10.9 while the average course grade score was 11.5. It is also important to note that 33 students enrolled in the course took the exam.

Chapter 6

Discussion

Theory into Practice

This study was greatly influenced by many scholars as discussed in chapter two. One scholar in particular was Rochelle Gutierrez. Most of the work that I cited is theoretical, and I was trying to see if that theoretical framework could be put into practice particularly in a university setting. My vision for equity has been heavily influenced by the scholars such as Gutierrez, but she does not supply a template to put this into practice at the university level, and this study is the first attempt. This study showed that with the implementation of such practices, students had better experiences of feeling supported and feeling like members of the class in the SJP section.

Support and Membership

While implementing the lessons in the SJP section and the textbook consistent lessons in the Standard section, I wanted to take a snapshot of how students were feeling at the time through this survey. The data sheds promising light on the effects of what such pedagogies can have on students. Overall the students in the SJP section felt like members of the course. In spite that there are several factors that can play a role in feeling supported, feeling like a member, and finding the lesson relevant, I would argue that through these lessons and homeworks, I was able to build rapport with my students over time. Allowing them to give me a snapshot into their lives allowed me to see how I can better assist them. These practices engage us in such interactions because they invite us to get to know our students beyond a superficial level.

Relevancy

From chapter five, we noticed that of all the EOP lessons, the SJP section found the unit circle the most relevant. I intentionally meant to make these lessons more relevant

that those of the Standard section, yet my efforts to make the unit circle relevant were not my greatest concern or objective. So why is it that my students from the SJP section found that lesson to be the most relevant? This leads me to question, what do I mean by relevancy and what do my students mean by relevancy. Perhaps relevancy is in reference to their identity and how it is affected by whether or not they are successful in the math.

Understanding/ Proficiency

One of the ongoing objectives of this study is ensuring that the students were understanding or getting the dominant mathematics. Through the exit ticket free responses, we can see that students from the SJP section overall provided more mathematical explanations in their exit tickets rather than simply writing notation or formulas Perhaps through the relevant lesson plans students were given the space to articulate and make connections of the mathematical content, and perhaps seeing the need for me to want to make connections and constantly provide rational influenced them to do the same on those exit tickets.

Along with observing understanding, the homework responses gave insight to new ways of thinking that I have never seen before. Students attempted to define composition of functions using water being frozen then being heated along with ones illustrated in Chapter Five.

Checking my Own Privilege

I had the opportunity to share my findings with my cohort. When I shared the composition of function mapping that I had made for my students that mapped my reality. One of them asked,

Andres points at the board: So did you talk about the domain?

Me: Yeah, we explored that mathematically.

Andres: No, I mean did you talk about who goes in the domain?

Me: Yes, we talked about the set being defined as members of the math 199 class.

Andres: No, I guess what I am trying to get at is what about people who are not born in a place with a zip code. Let alone street names.

Me: *damn*... (A. Rodriguez, personal communication, April 12, 2018).

Here I was thinking that I am coming up with this new way of looking at something that no one has seen before, and yet I managed to leave a good portion of my students out of the discussion. Mathematically, my work is sound with how I defined domain, yet with the hopes to include my students I only included those who were born in the United States of America. Here we see that my privilege of being born in the USA shaped the lesson. I never would have thought about it unless my colleague Andres pointed it out.

This is why diversity is so important when attempting to create a space for our students. This is not limited to individuals from your own department. You can allow it to be anyone.

Limitations

If I were to design this study again, I would want to observe more than two sections in order to increase the sample size. This would allow me to test for statistically significant differences. Along with increasing the number of sections observed, measuring cultural competence or students sense of agency or political consciousness is something that I would attempt to design. Measuring this sense of social agency may be a challenge, but one more qualitative approach is to have students at the end of the semester write and reflect on the ways in which the course has helped them see and operate in the world. Such a task can shed light on the self- perceived growth from the student.

Plan of Action.

The scholars such as Frankenstein, Gutstein, and Gutiérrez discuss the tensions of making sure students have access to the dominant mathematics while attending to notions of identity and power. I responded to that tension with a more dominant mathematics lesson for the third lesson involving the unit circle, and it was meaningful to the students because it was addressing their need to understand.

As scholars continue understanding how these different theories of EOP work together, one must realize that they are complimentary and not contradictor, which is why one theory alone is not enough. Therefore, collaboration is key to continuing this work. Additionally, scholars and educators need to not be afraid of doing or enacting lessons perfectly. For example, in the enactment of these lessons, I was able to do it in such a way that there was not too much risk to meeting the course objectives.

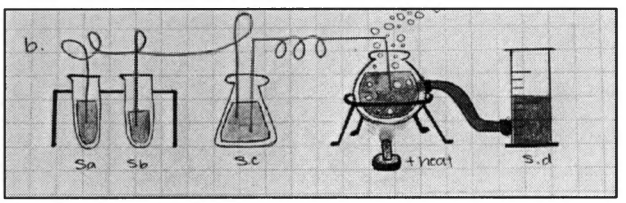
Ultimately, the challenge for scholars is to not be satisfied with success on the dominant access and to not allow their work for incremental progress to be sufficient. The larger systemic issues of oppression and injustice are played out through mathematics education and through the use of mathematics in the world.

Chapter 7

Conclusion

Papelito Guardado

Now I would like to end with a non-dominant traditional approach to my work. At the beginning of this study, I provided the first *papelito guardado* that helps shed light on how my experiences of marginalization in my K-16 experience help shape how I think about equity, thus how I attempt to invest and validate my students. I want to bring you back to this student's response from *figure 19*:



I felt vulnerable letting this be a low stakes homework assignment.

Diana: I hope that they take it seriously. I hope they can demonstrate that they know this stuff. No one knows if you are really doing your best. Am I doing my best in this instant to serve and to give? How can I get them to grow to be like us? To have access to the club and to have the mathematics.

Student*: I need your mathematics?... I need to be like you?*

Diana: How do I make this lesson relevant?

Student: *Relevant to me or relevant to my survival of the class? You see some of my classmates' identity will be affected by this path.*

Diana: I hope they can demonstrate the math. I hope they paid attention.

Student*: Sit down for a moment, let me show you my way profe. I will take your dominant math and give you a whole new dimension....I will do it my way.*

The reason why I bring you back to this student's homework response is because this is an instant like several others, in which a student took the dominant math and was critical about it. Many mathematicians believe the class is relevant because it is so important to us educators, but to some students surviving math is what is relevant in the sense that it impacts their identity. Thus, not necessarily relevant in the sense that the content is relevant. What I hear her saying, *"Your narrow dominant mathematical oriented mind, that is so far outside of the acceptable ways of defining shows how narrow your definition is of math."* And it was a student, a woman of color, who was more creative and imaginative, who took the definition of relevancy and membership and redefined it. She brought it to bear. Now the question is would I affirm it? Thus, extend membership criteria, thus support her involvement, and thus agree with her that it is relevant. This is a prime example that shows that I, in part, am redefining the moment of what it means to be a member as a gatekeeper.

She redefined membership in ways that myself and other mathematicians might have never conceptualized. But here is a good answer but not on traditional math terms. She extended the boundaries by which membership means. But the question is did I reject her membership card to the math community? This gives me the hope as a woman of color that I really need to listen to my students. We do not often think about them as *pensadoras* (female thinkers*)* we get caught up with wanting to give as they are lacking something.

I am showing you this because I am the one that has to grow, not her. In this example I grew, and I ask, "Our we really willing to listen to the *pensadoras* of our classroom?" I am the first gatekeeper who says this gets no credit. I am the interpreter in what students do that it is brilliant, that is insubordinate of the system, thus creating change in the system. And more importantly membership grows on different terms.

Summary

Throughout the three lessons, both the SJP section and the Standard section obtained differences between students feeling supported, feeling like members of the class, and finding the lesson relevant. The free responses did indicate that students did walk away with relevancy as one of the big takeaways with the lesson, which allows us to see that when creating CRP lesson plans, students can actually walk away with the connection/application being one the most important aspect of the lesson. With the MDTP results we can see that students from the SJP section still managed to perform as well as their peers in the Standard section, and more importantly we were able to see new forms of knowledge from students' homework responses.

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Appendix A-Bonus Homework

Bonus Homework
Due May 26th 11:59pm via email

Write an effective letter to senator Dianne or Kamala:

Dianne Feinstein
331 Hart Senate Office Building Washington
DC 20510
(202) 224-3841
Contact: www.feinstein.senate.gov/public/index.cfm/e-mail-me

Kamala D. Harris
112 Hart Senate Office Building Washington
DC 20510
(202) 224-3553
Contact: www.harris.senate.gov/content/contact-senator

Use the mathematics to establish your stance on the topic around student tuition. Several of you stated that it is not minimum wage that we need to focus on, but rather lowering tuition costs. This is your chance to articulate this matter more.

Establish a call to action or express your concerns to senator Feinstein or senator Harris with the use of the mathematics you used in class. Also include your personal story to make a more compelling argument.

I have attached some of the notes from that lesson in which we explored how:

- Students in 1985 worked only 199 hours at a minimum wage rate of 3.35 dollars an hour
- And in 2015 most of you had to work 682 hours at a minimum wage rate of 9.50 dollars an hour to pay off tuition.

(These stats do not even include the actual cost of tuition for us who are paying it with student loans)

Tell the senator what you learned: how much tuition should be if students in 2015 only had to work 199 hours of minimum wage work of 9.95 dollars . There's a big difference!

Here is a link to help you construct an effective letter:
https://www.thoughtco.com/write-effective-letters-to-congress-3322301

Appendix B- Composition of Functions Homework

Hand- in Homework 10

Due at the beginning of class March 27th.

Part 1:

Look over your notes and re-read article Equity Interrupted for small discussion. This article has been posted on ilearn. If you have issues downloading anything, contact me as soon as possible.

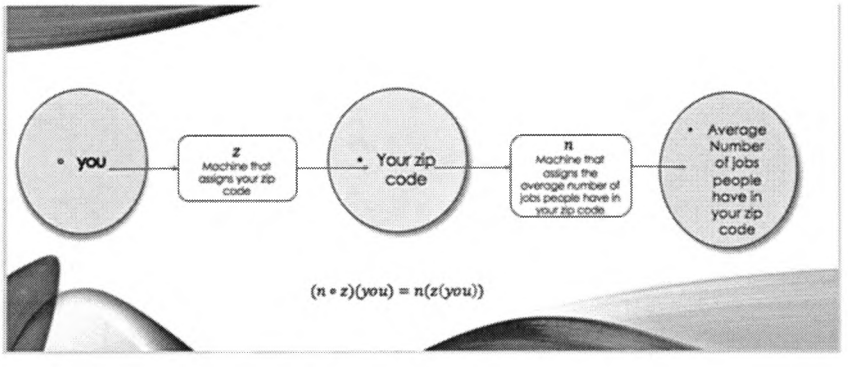
Part 2: (Let your imagination fly with this part!)

Last class, we covered **composition of functions** and how we may experience them. Answer and explore one of the following:

a. How would you describe compositions of functions to someone who has not taken algebra yet?

b. How can you reconstruct a composition of functions (or mappings) like we did in class that have **a positive outlook** rather than a negative fact?

For example, I presented the following composition of functions of n and z.



Part 3: (Optional)

Counter-narratives:
Were there any times in life where you felt misrepresented?

Appendix C- End of The Class Exit Tickets

(Front)

Name:_____
This will be turned into Dr. Seashore to code.

End of the Class Question

Briefly describe what you think were the important or big takeaways from today's class.

(Back)

Survey Questions
Please indicate how much you agree with the following statements.

Scale: 1= Strongly agree; 2=agree; 3=disagree; 4=strongly disagree

1. **I felt supported by my peers today.**
   (1) (2) (3) (4)
2. **I felt supported by the instructor today.**
   (1) (2) (3) (4)
3. **I feel a sense of belonging to this classroom.**
   (1) (2) (3) (4)
4. **I feel like my contributions were valued in class.**
   (1) (2) (3) (4)
5. **I feel comfortable in this class.**
   (1) (2) (3) (4)
6. **I see myself as a member of this class.**
   (1) (2) (3) (4)
7. **I feel like an important member of this class.**
   (1) (2) (3) (4)
8. **I found today's lecture meaningful to my life.**
   (1) (2) (3) (4)
9. **I found today's lecture relevant to my life.**
   (1) (2) (3) (4)
10. **I can use today's lecture to better navigate in the world.**
    (1) (2) (3) (4)
11. **I feel that I can use what I learned today as a tool to explain concepts to other people.**
    (1) (2) (3) (4)

Appendix D- Class Activity

Class Activity

Work or Study? #StudentProblems

Today we would like to explore the statement below using linear functions. But before we begin, make sure to introduce yourself to your group, and share with each other:

- How do you manage to balance studying for your classes and other commitments outside of school?

Today, we will be exploring the fact provided by members of the CSU Faculty Association:

"In 1985, CSU students had to work _____ hours at a minimum wage to pay tuition and fees for an academic year at the CSU.
In 2015, students had to work _____ hours at a minimum wage job to cover those costs."

Part I

1. Do you think this is true?
   Why or why not?

2. The job for today is to evaluate question number 1.

3. What sorts of questions does this bring up for you?

4. The minimum wage in CA was _____ 1985.
5. The minimum wage in CA was _____ 2015.

Our goal is to make sense of the previous statements using linear functions.

Appendix E- Class Activity Continued

- Definition: A **linear function** is a _____ between _____ **variables**, normally seen as an independent variable x and a dependent variable y.
- The **general equation**/form of a linear function is:_____
- What is so special about the **rate of change** of a linear function?_____

Part II.

1. With the previous information acquired in **Part I**, compare variables against other variables using linear functions.

(Do this on a separate sheet of paper)

2. Provide the corresponding graphs for the variables that you are comparting against each other.

Make sure to define your variables:

Let x =_____

Let y =_____

Part III.

Class Example

Variables used: x= _____ y =_____

****I will be providing a Scholarship Link on ilearn *******