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Transforming elementary preservice teachers' mathematical knowledge for and through social understanding

Transformar el conocimiento matemático de los futuros profesores de Primaria para y a través de la comprensión social

Transformar o conhecimento matemático dos futuros professores do Ensino fundamental para e através da compreensão social

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Elementary preservice elementary teachers (PSTs) often enter collegiate courses with limited mathematical understanding and narrow perspectives of critical social issues. This case study examines what happened to perceptions of mathematics knowledge as well as social issue knowledge when the two were integrated in a one-semester mathematics content course for elementary PSTs. Data analysis revealed parallels between mathematics and social issue knowledge early in the semester and at the end of the semester. Data also indicated that some participants exhibited signs of resistance to changing their initial knowledge and understandings.

Keywords: Social justice mathematics, Preservice teacher education, Elementary teachers.

Los maestros de primaria a menudo cursan estudios universitarios contando con una limitada comprensión matemática y comprensión de los asuntos sociales. En esta investigación examinamos tanto la percepción de los maestros de primaria sobre el conocimiento matemático y conocimiento social cuando ambos se integran en un curso de contenido matemático de un semestre de duración. El análisis de datos reveló un paralelismo entre las Matemáticas y el conocimiento social al comienzo y al finalizar el semestre. Los datos también indican que algunos participantes muestran señales de resistencia a los cambios en su conocimiento y entendimiento inicial.

Descriptores: Matemáticas de la justicia social, Formación docente, Maestros de primaria.

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Os professores do ensino fundamental com frequência cursam estudos universitários contando com uma limitada compreensão matemática e compreensão dos assuntos sociais. Nesta pesquisa, examinamos tanto a percepção dos professores do ensino fundamental sobre o conhecimento matemático e o conhecimento social quando ambos se integram em um curso de conteúdo matemático de um semestre de duração. A análise de dados revelou um paralelismo entre as Matemáticas e o conhecimento social ao começar e ao finalizar o semestre. Os dados também indicam que alguns participantes mostram sinais de resistência às mudanças em seu conhecimento e entendimento inicial.

Palavras-chave: Matemáticas da justiça social, Formação docente, Professores do ensino fundamental.

1. Introduction

The idea that today's world may arguably be facing its most detrimental period in history has been a fairly common assertion for some time now (Capra, 1996; Bender, Burns, Burns, & Guggenheim, 2006; D'Ambrosio, 2007). Concerns with problems such as poverty, terrorism, resource scarcity, and environmental degradation have risen in educational communities, and although seemingly unrelated to one another, Capra has contended that these social issues are connected and illustrate different symptoms of one problem, a crisis of perception. In light of these interconnected problems, teachers and scholars have increasingly begun to address the idea of teaching in more integrated ways (e.g., Powell & Frankenstein, 1997; Friere, 2000; Gutstein & Peterson, 2013; Wager & Stinson, 2012). These advocates for teaching for social transformation have contended that the purpose of all education should be social well-being –that even in subjects such as mathematics, the overarching goal of teaching and learning should be to develop critical conscious in an effort to create a more just world.

However, if a primary goal of teaching subjects such as mathematics should be connecting it to meaningful social issues, teachers need to enter their professions having experienced mathematics for social change and need to be prepared to teach it. This necessarily adds strains to the ongoing concerns of teacher education programs regarding pedagogical practices and content issues. Preparing preservice teachers (PSTs) in the United States for teaching mathematics for social change involves at least three significant issues. First, PSTs need to develop conceptual understandings of the mathematics they will teach, which are often lacking (Ball, Thames, & Thames, 2008; National Mathematics Advisory Panel, 2008; Young & Zientek, 2011). Second, PSTs need to develop deeper understandings of social problems, as their understandings are often limited (Castro, 2010). And third, PSTs need to form connections between mathematics and social issues for and through mathematics.

Although mathematics educators have been exploring the teaching of mathematics alongside social issues with PSTs (e.g., McLeman, & Piert, 2013; Gutiérrez, 2009; Wager & Stinson, 2012), and some literature on elementary education PSTs' perceptions of learning mathematics in this way exists (e.g., Aguirre, Zavala, & Katanyoutanan, 2012), it is still scarce. Therefore, this study explores what happened to one group of PSTs' knowledge when mathematics and social issues were integrated in a mathematics content course for elementary teachers.

2. Theoretical Framework

A focus on the connection between mathematics education and equity penetrated the mainstream expectations for all teachers with the publication of the equity standard in the National Council of Teachers of Mathematics' Standards document (2000). However, as early as 1987, Marilyn Frankenstein brought focus to a more equitable mathematics curriculum by contemplating bridging the divide between the natural construction of mathematical knowledge and academic mathematics with adult working-class learners. This has become a major concern for teaching mathematics for social change across all age levels (e.g., Bartell, 2011; Gregson, 2011) and has shed light on the idea that an academic mathematics is often viewed by students as mysterious, rule driven, and disconnected. That elementary education PSTs often enter teacher education programs with the same limited conceptual knowledge of academic mathematics as Frankenstein expressed concern about with her adult students has been well documented (Ball, Hill, & Bass, 2005; Authors, 2010; Young & Zientek, 2011). These limitations are often complicated with misconceptions of academic mathematical ideas and formulas. PST's tend to rely on memorized procedures and rules to do mathematics and often have difficulty explaining how and why their solutions work. Elementary PSTs tendency to view academic mathematics as inaccessible complicates the expectation that teachers will help their future students develop meaningful and deep conceptual understanding of mathematics.

Further, an equitable mathematics has become not only a matter of accessibility to an academic mathematics but also a way to reveal injustice in society and move students to action against oppression (e.g., Gutstein & Peterson, 2013). Revealing injustice in society necessitates an understanding of societal issues, and many PSTs in the United States enter their college courses with limited knowledge of society and social issues. They tend to be predominately European-American females, (United States Department of Education, 2007) with superficial understandings of complex cultural issues (Castro, 2010; Cochran-Smith & Zeichner, 2005). PST's limited understanding of social issues can hinder their abilities to use mathematics as a way to reveal inequity and help their future students become advocates of social justice.

In recognition of these challenges for PST education, this study explores two main theories for teaching mathematics to a group of PSTs—*relevant subject matter* and *constructivist theory of learning*. The first is the idea that both mathematics and social issues are more meaningfully understood when they intertwine with one another (Powell & Frankenstein, 1997; Gutstein & Peterson, 2013; Wager & Stinson, 2012). Almost a century ago, scholars such as Dewey (1902) and Whitehead (1927) called into question the abstract nature of teaching. They contended that the primary goal of education should be connecting education to the lives of students, not transmitting disconnected, seemingly irrelevant facts, which can actually hinder learning rather than stimulate it. Culturally relevant curriculum begins with understanding where students are coming from in order to decide how to intervene in the construction of new knowledge (Cochran-Smith, 1999). It is understanding how the student's culture can be a source for connection to the curriculum and revelation of a new understanding. Gregson (2011) studied the effects of a secondary teacher who understood the connections between mathematics and the world around her and her students. This case study highlighted the importance of connecting mathematics curriculum to relevant

subject matter and depicted a picture of a dynamic, fluid classroom, where meaningful conceptual mathematical understanding was evident. Therefore, it seems logical that if the PST should learn about the world and mathematics in a manner that is connected to her/his life, s/he may begin considering teaching in this way.

Teaching mathematics for social justice can bridge the divide between the abstract and the relevant by employing mathematics as a means of uncovering the effects of injustice. Understanding mathematics through a connection to world conditions can inspire a desire to learn mathematics and empower students to create change (Gutstein, & Peterson, 2006, 2013; Wager, & Stinson, 2012). Through problem-posing, mathematics can reveal the effects of injustice in Western culture and transform the subject into a "tool to understand and potentially change the world" (Gutstein & Peterson, 2006:2). Bartell (2011) and Gregson (2011) have documented, through their research, the importance of teachers forming connections between mathematics and social issues, inferring that the mathematics traditionally taught in classrooms across the United States tends to benefit middle- and upper-class European-American students more than other cultural groups and limits accessibility of academic mathematics to other cultural groups, often times perpetuating injustice rather than combating it. In theory, if PSTs experience and see meaningful connections between mathematics and the world around them, they are more likely to develop critical conscience regarding social issues as well as conceptual understanding of mathematics, and use mathematics in practical and applied ways not only for mathematical understanding for themselves and their students but also for the contemplation of social change.

The second theory this study utilized is the idea that knowledge must be actively constructed and socially verified. Constructivist theories of learning suggest that listening to a perceived authority is insufficient for the development of knowledge (von Glasersfeld, 1995). Teachers should pose mathematical problems and ask students to experience mathematics in multiple and individualized ways in order to form connections and develop their own understandings. Students should interact with one another to explain and defend their thoughts in order to begin to understand their own thinking, gain confidence in their ideas, and author their own learning processes (Powell & Frankenstein, 1997; Reeder, Cassel, Reynolds, & Fleener, 2006). Frankenstein (1987) used dialogue as a way to work side-by-side with her adult students on mathematics and helped them understand that mathematics is constructed socially, often stemming from a Eurocentric perspective that maintains the status quo. If PSTs engage in activities and experiences that support problem-centered learning approaches to teaching and learning mathematics (Wheatley, & Abshire, 2002; Van de Wall, 2004), theoretically, they will actively construct deeper and more conceptual understandings of academic mathematics.

However, providing space and opportunity for PSTs to form connections between issues of equity and mathematics is often more complex than simply connecting mathematics to relevant social justice issues and doing so in an active learning environment. Aguirre, Zavala, & Katanyoutanan (2012) contended that similar to other research (e. g., Aguirre, 2009; Gutiérrez, 2009) tension can continue to exist in fully embracing a social justice mathematics curricular knowledge and implementing such a curriculum in the classroom when pre- and in-service teachers have not had multiple and ongoing experiences with social justice mathematics. Simply taking one course or having some exposure to equitable mathematics might not be sufficient for transforming either

content or pedagogical knowledge of mathematics and social issues. More resources are needed to support teachers in continuing their education of social justice mathematics and the enacting of learning environments that support such mathematics lessons.

3. Methodology

3.1. Setting and Participants

Data for the study were collected in a community college class in a city in the Southwestern region of the United States. The nineteen participants in the study were female, ranging in age from eighteen-years-old to their mid-forties. Most of the PSTs in the study were European-American, native speakers of English. Seven of the participants spoke English as their second language, six spoke Spanish and one spoke Korean as their native languages. All participants had passed at least one pre-requisite college mathematics course before entering this class or had passed a placement exam for entrance into the course. This was the first of two required mathematics courses, at the community college, for prospective elementary teachers. The class met once a week for fifteen weeks.

3.2. Overview of the Methods Course

The basic premise of the course was to help PSTs develop number sense, to better understand local and global problems through mathematics, and to contemplate what it means or should mean to live, teach, and learn in a democratic society. The curricular objectives for the course focused on number and arithmetic operations and centered specifically on whole numbers, integers, fractions, decimals, percentages, irrational numbers, and sets. The social objectives focused on social growth, or the development of a more comprehensive understanding of social issues for and through the development of the mathematical skills needed to understand critical social issues. Social issues such as healthcare reform, the ethics of sweatshops, television advertising, and poverty were integrated into the curriculum throughout the semester, often times with the aid of the arts (i.e., children's stories, newspaper articles, video clips, etc.). Approximately one-third of all the lessons explicitly incorporated at least one social issue.

The objectives for the course were addressed through several key activities and pedagogic components: Journal activities, closed book journaling, small group discussion, and whole-group discussion. Journal Activities were assigned every week. The instructor deliberately selected activities meant to engage PSTs in developing conceptual understandings of mathematics and finding connections between mathematics and meaningful social contexts. Tasks were constructed with PST interest in particular social issues and the mathematical objectives of the course in mind.

Activities were assigned to students each week for the duration of the fifteen weeks semester. Although some introduction to the problems would take place during class, students were expected to grapple with these on their own time and at their own pace for one week before they were discussed in class. Each week, the Journal Activities from the previous week would be discussed in groups and with the entire class. Students recorded all journal activity work in a journal for the course. They were allowed to revisit and re-work problems at any time during the semester, even though journals were graded twice before the end of the semester. They submitted completed journals during the final class period. All revised work was graded a second time.

Each week's journal activities were aligned with exposure to and experience with a particular mathematical concept in mind. Often the topics were embedded within a social context that addressed a critical social issue. Although the activities, problems, and scenarios included in the journals were created to address particular mathematical ideas, they provided opportunities for exploring multiple concepts, procedures, and solutions for mathematics and social issues. For example, one activity asked the PSTs to explore the concept of exponential growth. The children's story One Grain of Rice (Demi, 1997) was used to exhibit the social issues of greed, power, and wealth. During their investigation, PSTs wrote about and discussed exponents, factors, multiples, patterns, summation notation, and variables. Although the primary focus of the lesson was to engage students in understanding exponential growth, PSTs worked with multiple concepts and ideas simultaneously, considering social problems as well as mathematics to understand much more than exponential growth. These journal activities were embedded within a classroom community that revolved around curricular routines and provided students with the opportunity to engage in thinking about mathematics and society. The curricular routine followed the pattern described next.

Closed-Book Journals (CBJs, similar to short quizzes) were generally administered at the beginning of each class period and included answering one or more questions about a topic or topics that had been encountered previously. The instructor read and responded to CBJs before the next class period, and often asked PSTs questions to either elaborate their thinking or perturb it. PSTs were allowed to redo these for full credit.

Small-Group Discussions were utilized as an initial way for four to five PSTs to discuss and answer questions from the Journal Activities or CBJ for the week. The instructor asked PSTs to do three things during this time: "(1) Stay on task, (2) Do not move to a discussion of a new problem or assignment until everyone in the group feels comfortable with the solution because I will ask PSTs randomly to discuss any problem, and (3) After an adequate amount of time, if a problem or discussion cannot be resolved within the group, record it so that it may be addressed to the whole-class later."

Whole-Class Discussion would take place after small-group discussions had concluded. During this time, PSTs would present problems or ask questions that remained unresolved from group discussions. This was also the time she would ask questions such as, "Did anyone solve this problem in a different way? Do you agree or disagree with this? Why or why not? Does anyone have anything else to add or share? What other ideas would you be interested in investigating?" Her intention during these discussions was to perturb thinking, encourage diverse methods of solving problems, and support PSTs to interject other ideas and opinions about mathematics or social issues. It was during these discussions that many of the social issues chosen for integration in the curriculum emerged.

3.3. Data Collection and Analysis

This study utilized a qualitative research design that incorporated case study (Stake, 1995) and practitioner-research (Anderson, Herr, & Nihlen, 1994). Data were collected in the form of a reflective journal completed weekly by the instructor (also researcher), PST work (which included written reflections), recorded classroom discussions, and recorded informal interviews (conducted outside of class). Upon completing data collection, a data analysis spiral (Cresswell, 2007) approach was used to find analytical

themes. Reflective examination of data occurred throughout the semester; however, formal data analysis included the development of an overall idea of PST perceptions through successive examinations of the instructor journal, PST journals, and audio/video recordings. Audio/video recordings were transcribed, and several spirals back through the data were performed to verify the formation of themes from which answers to the research question could be identified.

Themes that emerged included parallel themes between initial knowledge and transformed knowledge as well as resistance to change in knowledge. Parallel themes were only included if ten or more PSTs' responses supported them. Although the parallel themes indicate the meaningful change that several of the PSTs went through as a result of taking this course, some PSTs encountered resistance to change. These observations emerged as a resistance to change them and only appeared periodically throughout the semester, from fewer than 10 PSTs. It is difficult to give an exact number of PSTs who resisted change in some cases as some findings emerged from conversations within groups, where it was unclear exactly how many PSTs were participating in the discussions. The findings were included under Resistance (below) and did not indicate that no change in knowledge had occurred for these PSTs, merely that there were certain areas where a resistance to change was observed by the researchers in particular conversations or journal entries.

4. Findings

Analysis of the data revealed parallels, throughout the semester, between PSTs' knowledge of both mathematics and social issues when they were intertwined in this problem-centered learning environment. However, some PSTs exhibited resistance to change in knowledge. These parallels in initial knowledge and transformed knowledge are presented first, and the resistance to change in knowledge follows.

4.1. Initial Knowledge

Data revealed that meaningful knowledge of both mathematics and social issues was initially limited. Initial knowledge was considered to be the knowledge the PSTs exhibited in the early stages of exposure to a topic, typically before spending much time grappling with a particular topic or issue, or the prior knowledge the PSTs described having when reflecting on their knowledge before making connections in this course. Consistent with other research regarding elementary PSTs mathematics content knowledge (Ball, Thames, & Thames, 2008; Young, & Zientek, 2011), when PSTs were prompted to initially speak and write about particular academic mathematics topics or when they reflected on their prior knowledge of such topics, they seemed to demonstrate a limited initial conceptual knowledge of the subject. Similarly, PSTs had difficulty describing social issues with depth when they reflected on their knowledge of the issues prior to exposure in this class or when they were asked to speak or write about them.

Limited Mathematical Knowledge. This group of elementary PSTs' limited mathematical knowledge was revealed in multiple ways during initial exposure to various topics. For example, during an early discussion of fractions, one PST explained that she always "skipped those problems" when she encountered them on exams or in

homework and another PST said, "I never learned fractions when we did them in school." In one informal interview, a PST said:

> *Percentages are clueless to me. I wish I could learn them, because I go to the store and it will say "20% off" and I'm like "man, okay, how much is that?" I hate it when I can't figure it out.*

During a discussion of multiplication of fractions, after letting PSTs grapple unsuccessfully with explanations as to why we multiply the numerators and the denominators, PSTs were asked to describe how they thought about multiplication of whole numbers. The discussion of this topic formed a connection for one PST which prompted her to say, "I had no idea you could think of multiplication of fractions in the same way." Several PSTs affirmed this statement. During another discussion, PSTs were asked to find 20% of the United States' population. One PSTs said she divided by five to do this, another PST commented that she used a formula for finding 20%, a third PST explained that she found the figure by finding 10% and doubling it, and a fourth PST said she multiplied by 0.2. The various ways of finding 20% yielded a lengthy discussion about the similarities between percentages, decimals, division and benchmarks. Many PSTs expressed their surprise by these links.

For several PSTs, limited mathematical knowledge seemed to stem from superficial constructions of mathematics. For example, during an early discussion of multiplication of integers, almost every PST could supply the rules for multiplying positive and negative numbers, but not one could explain the logic of all the rules. Most PSTs defended procedures with statements such as, "that's the rule" or "because my teacher said so," and one PST wrote in her journal:

> *I've never thought about the mathematical fundamentals which the formula derived from real examples, but just memorized formula, substitute some numbers for X or Y in it, and did the mechanical calculations.*

During an initial discussion about multiplication of multiple-digit numbers, one PST said, "I thought I understood how to multiply a two-digit number with another two-digit number, but it never occurred to me why we scoot over on the second line." She had always used the procedure but never thought about the logic of performing the calculation in this way.

Even more detrimental, several PSTs revealed their limited knowledge with their use of incorrect mathematics. For example, during our first whole-class discussion of operations with fractions, PSTs were asked to tell the instructor what they knew about multiplication of fractions. One PST said, "Don't you need a common denominator?" She was using the rule for addition of fractions and applying it to multiplication of fractions. Yet on another occasion, when students were asked what they could tell the instructor about integers, a PST proposed that for addition of integers, "when the signs are different, your answer is negative and when the signs are the same, your answer is positive," applying the rule for multiplication of integers to addition of integers.

Parallel Limited Social Issue Knowledge. Similarly, the PSTs in this study revealed a limited knowledge of social issues in multiple ways when they encountered them for the first time in the class or when they reflected on the encounters they had in the course. For example, when PSTs were asked to reflect on their knowledge of social issues, one PST wrote, "Personally, I don't follow what President Obama is doing…" An international PST wrote, "I really had trouble to understand what is the current health

insurance system in the United States. Besides, the idea of health care reform made me more puzzled…", while another PST stated, "I do not follow politics very much…"

During a discussion about poverty in our state, PSTs discovered that approximately sixteen percent of the population lives in poverty. The instructor wrote in her reflective journal that PSTs seemed surprised by the figures. In another activity, while PSTs learned about sweatshop worker wages and conditions, several realized that sweatshops exist in the United States. PSTs made comments like, "I didn't know we have sweatshops here. I thought they were only in other countries." As PSTs reflected on the lessons we did, many wrote about being astonished by the limited knowledge people have of critical social issues. One PST wrote, "I learned how little most people truly know about very important subjects."

Although most PSTs had some exposure to the social issues that emerged in this class, just as with the mathematics they explored, their knowledge was often superficial. For example, in a reflection, the instructor noted one PST objecting to health care reform "because doctors would make less money, and no one will want to be a doctor." When asked how much doctors would make, the PST answered, "I don't know, thirty or forty thousand." She believed she had a solid argument, but it was limited to a superficial statement, not a supported understanding.

Moreover, some PSTs illustrated their limited knowledge by using one or two examples as substantial evidence of an argument. For example, one PST wrote in her journal:

> *Doctors don't make money through Medicaid or Medicare…when I was 18 years I used to work with a Dr and his wife used to put things in the forms that was not even done to the patients so they could get more money. By the time I retired and want to get Medicare, there is not going to be any…*

On several occasions, the instructor noted in her reflective journal that PSTs would use phrases such as "I think," "I believe," or "In my opinion" to describe their perspectives of issues encountered. One PST described poverty as a problem because, as she put it, "I think people are just lazy and don't wanna get a job." Another PST objected to this statement and explained that she believed that a lot of those people "can't get a job." She too, explained this as her opinion. Generally, the PSTs did not find it necessary to verify their claims with supportive data.

Further, some PSTs seemed to have inaccurate knowledge of social issues. For example, before a mathematical healthcare debate, one PST wrote in her journal, "I don't find it right for me to pay for someone else's healthcare." She had explained that her opposition to healthcare reform stemmed from this reason. She seemed not to recognize that she pays for uninsured citizens' healthcare under the current system. Further, several PSTs agreed that they opposed healthcare reform because, as one PST put it, "People with socialized medicine pay more for healthcare." However, during the healthcare debate, after conducting their own research, PSTs discovered that Americans pay more for healthcare per capita than any other industrialized country in the world.

4.2. Transformed Knowledge

As PSTs interacted with one another, the instructor, and the curriculum, they began to transform their knowledge of both mathematics and social issues. They began to discuss and write about mathematics and social issues with more depth. Transformed knowledge was considered the knowledge that exhibited a shift in understanding that emerged during or after the grappling with mathematical topics and social issues

addressed in this course. Although other mathematics educators have found that when PSTs actively and socially construct mathematical knowledge, they begin to view the subject in more meaningful ways (e.g., Young, 2002; Reeder, Cassel, Reynolds, & Fleener, 2006), this study seemed to reveal that social issue knowledge transformed in a similar fashion when it was intertwined with mathematics. Over the course of the semester, many PSTs began to not only see connections among mathematical content and social issues but also between the subjects, forming connections between mathematics and a world outside of the classroom. By the last day of class every PST had either written or spoken about how this course helped transform her understandings of both mathematics and social issues.

Meaningful Mathematical Knowledge. After exploring mathematics through tasks that addressed the meaning behind the mathematics and connections to social issues, many elementary PSTs wrote about how engaging in this course increased mathematical conceptual comprehension for them. One PST wrote,

> *I definitely feel I learned a lot from this class. Mostly, I have learned the concepts behind the math problems that I've been doing my whole life which I thought was very important, and I realized that the way I had been taught was kind of sad in a way! I was taught repetitive procedures and had no clue as to what was behind the concept…*

After a discussion about fractions, one PST said, "I've been through elementary school, middle school, high school, and two college math classes and I never understood fractions the way I understood them in this class."

As PSTs began to construct more meaningful understandings of mathematics, they began to understand their own capabilities to construct an understanding of academic mathematics. One PST wrote, "I am gaining confidence and an increase in familiarity with problem solving and hopefully logic and reasoning…" Another wrote, "The main thing that impacted me was your teaching style. I really hope to be able to encourage my students to learn by letting them figure it out on their own like you did with us…" And a third PST wrote, "I think the thing I like the most about it [the class] is being able to figure out the problems…A lot of times it takes me a little bit of extra work to figure things out. But that ['s] okay."

Asking PSTs to construct their own knowledge using multiple procedures and methods such as working with manipulatives, drawing pictures, and connecting topics to previously encountered mathematics impacted perceptions of how mathematics should be done. For example, one PST wrote, "I learned that there isn't just one way to solve a math problem. You don't always have to remember the 'rules'. You can use base ten, fraction bars and other manipulative kits…" While another PST wrote, "I definitely learned more about fractions! Thinking of it as multiplication and benchmarks helped…"During a discussion of decimals, one PST said, "I never thought to use base-ten blocks when working with decimals, but they really help."

Transcending the traditional boundaries of mathematics learning led some elementary PSTs to further question mathematically. For example, while studying sets and whole numbers, one PST noticed that every time she would subtract two odd numbers, she would obtain an even number. She asked the instructor if she thought that this would always be the case. The instructor redirected the question to the other PSTs, and by the end of the class session, a PST illustrated a proof of the conjecture that "an odd number minus an odd number equals an even number." In another class period, the instructor observed a PST noticing a pattern when working with exponential growth. The PST

proposed the pattern to the class, and the class worked together to verify it. It was an unexpected result that led to a discussion of summation notation and how finding a pattern can lead to writing a formula.

Parallel Meaningful Social Issue Knowledge. Many of the elementary PSTs initial discussion and reflections about social issues depicted preconceived opinions that could not be described or supported concisely and clearly. However, after exploring the issues through mathematics, most of the PSTs in the class began writing about the issues with much more depth and understanding. As PSTs reflected on the healthcare debate in their journals, one PST shifted her stance on the issue and included in her journal:

> *The U.S. spends far more than any other industrialized nation on healthcare. Yet, other nations insure everyone while America has 46 million uninsured, a number which will grow as health insurance costs rise…*

Opinions about healthcare reform began to shift from opposition to favor. By the end of the debate, a more holistic understanding of this social issue persuaded more PSTs to not only support healthcare reform but also favor a universal healthcare system. For example, one PST wrote:

> *According to statistics from 2003, the United States spends $5,711 per capita per year for health care while Canada spends about half of that, $2,998 per capita per year (Kaiser Family Foundation, 2007)… socialized healthcare does work.*

Another PST journal reflected:

> *I learned a lot of great statistics from the debate. I learned that socialized healthcare would benefit more people than it would hurt. ..Socialized healthcare is established in many countries…This program is working perfectly fine in these countries.*

They began forming judgments about mathematics and social issues based on a more explicit mathematical understanding of issues rather than simply relying on belief and opinion.

As PSTs' understanding and confidence grew, they began to support their newfound social ideas and to question one another's knowledge, asking others for evidence to claims. During the classroom debate, one PST supplied a figure for the cost of healthcare reform on families in the United States and was challenged by a peer who referenced a different figure that showed a lowering of cost for families in the U.S. On another occasion, the instructor reflected in her journal about one PST making a comment regarding sweatshops and another saying, "Where did you get that information, because I found something different?" PSTs seemed to be viewing a meaningful understanding of social issues as based on evidence rather than unsupported statements and opinions.

Elementary PSTs also seemed to become more critical of their own understandings. One PST wrote about herself, "To be honest I did not know a thing about this healthcare reform…This is bad for me because I should be informed." The recognition of their limited knowledge convinced some PSTs to advocate teaching for social understanding. One PST wrote, "Incorporating math into those everyday things is so important, especially for kids because we should be teaching them to become better PEOPLE, not just better STUDENTS!!" Another PST included in her journal,

> *We reclaim society from giving attention, rediscovering on many controversial social issues. Throughout this process we can find possible answers. Teachers are not people who hand*

> *down only scholastic knowledge to the next generation, but also help them to build desirable insight into our social problems…*

Holistic Knowledge. When the elementary PSTs began to understand mathematics and social issues in more meaningful ways through the lessons they engaged in, they seemed to form connections that expanded their notions of both mathematics and social issues and the connections between the two. Social issues became mathematical, and mathematics became a social issue. PSTs began to understand important relationships between mathematics and social issues. One PST wrote,

> *As a student of the math class, I realized that we are using "MATH" a lot in our real life, not only calculating for our receipt in a store but also reading what happens in our community. Statistics and many kinds of graph can convey a whole story…*

Another included the comment that "these lessons made me think outside of my personal box. Additionally, the lessons showed me just how important math is in our daily lives." Further, in their reflective journals, PSTs wrote about their newfound inquiries of social issues. One PST noted that "[t]he lessons on social issues I think helped the class not only to incorporate and think about the math within the subject, but sparked further interest in the issue itself…" Another PST reflected, "I found that I would continue to think about these issues days and weeks after the lesson had concluded…" And another wrote, "I learned that I have many more questions economical, fiscal, financial and political."

Engaging these PSTs in mathematics linked with social issues deepened their understandings of both mathematics and social issues, helped them formulate and defend their knowledge in their own ways, and began to bridge the divide that existed for many of them between mathematics and the world outside the classroom. Further, engaging these PSTs in this type of integrated learning sparked an interest in the mathematics and the issues, encouraging PSTs to continue to explore them, even when they were not deliberately addressing them in class. These PSTs began to value a meaningful understanding of mathematics and social issues, even advocating educating for social well-being.

4.3. Resistance

Although most of the students' understandings of and beliefs about mathematics changed, for some, change was not inevitable after engaging in the activities and lessons included in this course. For some PSTs, the change they encountered was limited to the mathematics they engaged in as part of this class. At the end of the semester, some students expressed that they viewed the mathematics of this course as different from other mathematics and continued to harbor many of their initial beliefs about the subject when they wrote and spoke about other mathematics courses. For example, one PST wrote in her journal, "I do not know if this approach would work for all math classes but I was grateful to be a part of it and I am looking forward to incorporating some of these ideas in to my classrooms if given the opportunity…" Another PST wrote, "Higher math did, and still does seem kind of pointless, but my opinion is changing." Further, during a classroom discussion, the instructor noted one group of PSTs discussing enjoying "the way we do math in this class." They went on to explain they did not believe this approach could be taken in an Algebra course or any other upper-level mathematics course.

Moreover, in their final reflections for the course, three PSTs depicted that they still maintained some of their initial perceptions about mathematics and themselves as mathematical thinkers. One PST wrote "I still struggle with math so there where many different weak points for me. I always struggled with the homework…" and another expressed that "math is something that I really need to work on. I need to practice a lot and really retrain myself in my ways of thinking about math…"

Just as was the case for understandings and beliefs about mathematics, for some PSTs, the end of the semester did not reveal change in their knowledge of certain social issues or it only brought about change in their understandings and beliefs about social issues encountered in this class. Some of these PSTs continued to hold onto many of the initial beliefs they had regarding issues before they were studied in the class when they wrote and spoke about them after engaging in the lessons that addressed them. One PST continued to believe that healthcare reform would be more costly than the current system, while another wrote,

> *I learned that many people have many different opinions about Universal Healthcare. ..This type of healthcare could benefit many people, but at the same time it could place a higher burden on the people who then must chip in to support everyone else, as well as the people in the medical field…I say no Universal Healthcare because I don't find it right for me to pay for someone else's healthcare if they're doing things that are harmful to their health, or if they are too lazy to go out and get a job.*

She continued to believe that she would have to pay for those who are uninsured, even though several students presented data that illustrated how much Americans pay for uninsured individuals through the current private healthcare system.

At the end of the semester, the PSTs in this course presented a project that described the mathematics behind a social issue of their choice. One PST chose abortion, and in her presentation, she used mathematical evidence to illustrate why she opposed abortion. However, in her explanation, she only used mathematical information to support one side of the debate. Although she had stressed the importance of investigating the complexity of an issue before making a decision in her healthcare debate journal reflection, she failed to investigate both sides of the abortion debate before making a decision about the issue. Even though understanding healthcare reform prompted her to change her opinion drastically from a position that did not support healthcare reform to one that supported a universal healthcare system, which she attributed to researching more than one side of the issue, when she encountered another topic of social concern, she reverted to describing it from the perspective of her political affiliation.

It is difficult to determine why some PSTs continued to see mathematics and social issues in the ways they initially did, as described here. It could be a result of the many years of experience in traditional mathematics classroom settings, or it may be other factors. Further research is needed to determine what exactly sustained these beliefs for some PSTs in this course. Regardless, while this resistance to change was the case for some, it was only so for a minority of the class.

5. Implications for Mathematics Education

What happened to one group of elementary PSTs' knowledge of mathematics and social issues when they were taught in conjunction with one another? What does this study

suggest for mathematics education? The data in this study illustrated not only the mathematical but also the social growth the PSTs experienced. The findings of this study suggest that mathematical and social understanding can be meaningfully integrated in a mathematics content course for elementary teachers. However, integrating mathematics and social issues does not make success inevitable. The examples presented in this paper do not encompass the totality of why this approach seemed to overall succeed in this course nor do they depict the limitations to this approach to teaching. For example, it took several weeks for the PSTs to "buy in" to this learning approach, which was not addressed in this paper.

We recognize that rarely are experiences in any class as simplistic as they are often presented in papers such as this. The complexity of classroom interactions interwoven with instructor relationships with PSTs, the rapport developed between PSTs, and the social norms established all play critical roles in the success of any teaching endeavor. Although we believe the results are accurate, many factors of the class could not be described in this paper. Therefore, it is important to note that maximizing mathematical and social understanding is not limited to incorporating social issues into the mathematics curriculum, but rather that doing so can aid in this process.

With this in mind, the findings suggest that the elementary PSTs in this study responded well to the integration of social issues into this mathematics class. Consistent with other scholars' (Dewey, 1902; Gutstein, & Peterson, 2013; von Glasersfeld, 1995; Wager, & Stinson, 2012; Whitehead, 1929) suggestions that education is better understood when it is relevant, actively constructed, and socially verified. Connecting mathematics to social issues in this problem-centered learning environment supported these PSTs' interest in and understandings of both mathematics and social issues. The findings align with existing research that suggests elementary PST's often enter their college mathematics courses with limited knowledge (Ball, Thames, & Thames, 2008; National Mathematics Advisory Panel, 2008; Young, & Zientek, 2011) but also suggest that change in that understanding can occur over a fairly short period of time. The findings further imply that when social issues and problem-centered learning are incorporated in meaningful ways, PSTs can become motivated to learn both mathematics and social issues and develop more holistic understandings on their own; however, meaningful knowledge is not inevitable. These findings align with existing research that integrating social issues and mathematics can lead PSTs to deeper understandings of an academic mathematics and connections to social issues (Aguirre, 2009; Aguirre, del Rosario Zavala, & Katanyoutanant, 2012; Gutiérrez, 2009); however, limited experiences with such pedagogy and content may not sufficiently shift PSTs initial bias' and limited, superficial understandings. Therefore, the findings of this study would advocate creating a space where creativity in mathematics emerges by centering class time on relevant discussions. However, we would also emphasize that PSTs need multiple and ongoing experiences with mathematics for social change. Taking one course that addresses mathematics and social issues is only one component of developing successful teachers with deep content and pedagogical knowledge. Teaching mathematics for social change is an ongoing process of understanding the complex relationships that exist between the teacher, the curriculum, the world, and the student.

References

Anderson, G.L., Herr, K., & Nihlen, A.S. (1994). *Studying your own school: An educator's guide to qualitative research.* Thousand Oaks, CA: Cortin Press, Inc.

Aguirre, J.M., del Rosario Zavala, M., & Katanyoutanant, T. (2012). Developing Robust Forms of Pre-Service Teachers' Pedagogical Content Knowledge through Culturally Responsive Mathematics Teaching Analysis. *Mathematics Teacher Education & Development, 14*(2), 113-136.

Aguirre, J. (2009). Privileging mathematics and equity in teacher education: Framework, counterresistance strategies and reflections from a Latina mathematics educator. In B. Greer, S. Mukhopadhyay, S. Nelson-Barber, & A. Powell (Eds.), *Culturally responsive mathematics education* (pp. 295-319). New York: Routledge.

Ball, D.L., Hill, H.C., & Bass, H. (2005). Knowing mathematics for teaching: Who knows mathematics well enough to teach third grade, and how can we decide? *American Educator, 29*(3), 14-22, & 43-46.

Ball, D., Thames, M., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education, 59*(5), 389-407.

Bartell, T. (2011). Caring, race, culture, and power: A research synthesis toward supporting mathematics teachers in caring with awareness. *Journal of Urban Mathematics Education, 4*(1), 50-74.

Bender, L., Burns, S., Burns, S.Z., & Guggenheim, D. (2006). *An inconvenient truth.* New York: Lawrence Bender Productions.

Capra, R. (1996). *The web of life.* New York: Anchor Books.

Castro, A.J. (2010). Themes in the Research on Preservice Teachers' Views of Cultural Diversity Implications for Researching Millennial Preservice Teachers. *Educational Researcher, 39*(3), 198-210.

Cochran-Smith, M., & Zeichner, K. (Eds.). (2005). *Studying teacher education: The report of the AERA Panel on Research and Teacher Education.* Mahwah, NJ: Lawrence Erlbaum.

Cochran-Smith, M. (1999). Learning to teach for social justice. In G. Griffin (Ed.), *The education of teachers: Ninety-eighth yearbook of the National Society for the Study of Education* (pp. 114–145). Chicago, IL: University of Chicago Press.

Cresswell, J.W. (2007). *Qualitative inquiry and research design: Choosing among five approaches, 2nd edition.* Thousand Oaks, CA: Sage.

D'Ambrosio, U. (2007). Peace, social justice and ethnomathematics. In B. Sriraman (Ed.), *International Perspectives on Social Justice in Mathematics Education. The Montana Mathematics Enthusiast* (pp. 25-34). Retrieved from http://www.math.umt.edu/TMME/

Demi. (1997). *One grain of rice: A mathematical folktale.* New York: Scholastic Press.

Dewey, J. (1902). *The child & the curriculum.* Chicago, IL: The University of Chicago Press.

Frankenstein, M. (1987). Critical mathematics education: An application of Paulo Freire's epistemology. In I. Shor (Ed.), *Freire for the classroom: A sourcebook for liberatory teaching* (pp. 180–210). Portsmouth, NH: Boyton/Cook.

Freire, P. (2000). *Pedagogy of the oppressed.* New York: Continuum.

Gutiérrez, R. (2009). Embracing the inherent tensions in teaching mathematics from an equity stance. *Democracy and Education, 18*(3), 9–16.

Gutstein, E., & Peterson, B. (Eds.). (2006). *Rethinking mathematics: teaching social justice by the numbers*. Milwaukee, WI: Rethinking Schools.

Gutstein, E., & Peterson, B. (Eds.). (2013). *Rethinking mathematics: teaching social justice by the numbers*. Milwaukee, WI: Rethinking Schools.

Gregson, S.A. (2013). Negotiating social justice teaching: One full-time teacher's practice viewed from the trenches. *Journal for Research in Mathematics Education, 44*(1), 164-198.

McLeman, L., & Piert, J. (2013). Considering the Social Justice Mathematical Journey of Secondary Mathematics Preservice Teachers. *Journal of Urban Mathematics Education, 6*(1), 1-24.

National Council of Teachers of Mathematics (NCTM) (2000). *Principles and Standards for School Mathematics*. Reston, VA: NCTM.

National Mathematics Advisory Panel. (2008). *Boards and Commissions Reports*. Retrieved from http://www2.ed.gov/about/bdscomm/list/mathpanel/reports.html

Peterson, B. (2006). *Analyzing the Barrage of Advertising Aimed at Children* In E. Gutstein, & B. Peterson (Eds.), *Rethinking mathematics: teaching social justice by the number* (pp. 56-78). Milwaukee, WI: Rethinking Schools.

Powell, B., & Frankenstein, M. (Eds.) (1997). *Ethnomathematics: Challenging Eurocentrism in Mathematics Education*. Albany, NY: State University of New York Press.

Reeder, S., Cassel, D., Reynolds, A., & Fleener, M.J. (2006). Doing something different: Envisioning and enacting mathematics curriculum alternatives. *Curriculum and Teaching Dialogue, 8*(1-2), 51-68.

Stake, R. (1995). *The art of case research*. Newbury Park, CA: Sage Publications.

United States Department of Education. (2007). *Digest of Education Statistics: 2007*. Retreived from http://nces.ed.gov/programs/digest/d07

Van de Walle, J.A. (2004). *Elementary and middle school mathematics: Teaching developmentally*. Boston, MA: Pearson.

Von Glasersfeld, E. (1995). *Radical constructivism a way of knowing and learning*. New York: Routledge Falmer.

Wager, A.A., & Stinson, D.W. (Eds.). (2012). *Teaching mathematics for social justice: Conversations with educators*. Boston, MA: National Council of Teachers of Mathematics.

Wheatley, G.H., & Abshire, G. (2002). *Developing mathematical fluency: Activities for grades 5-8*. Tallahassee, FL: Mathematics Learning.

Whitehead, A. (1929). *The aims of education*. New York: Macmillan.

Young, E. (2002). *Unpacking mathematical content through problem solving*. Unpublished doctoral dissertation. University of Oklahoma, Oklahoma.

Young, E., & Reichwein Zientek, L. (2011). Fraction operations: An examination of prospective teachers' errors, confidence, and bias. *Investigations, 4*(1), 1-23.