

RUNNING TITLE: Everything is Math

“Everything is Math in the Whole World:” Teaching Mathematics for Social Justice with Elementary Latino/a Students in An After-school Setting

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This research was supported by the National Science Foundation, under grant ESI-0424983, awarded to CEMELA (The Center for the Mathematics Education of Latino/as). The views expressed here are those of the authors and do not necessarily reflect the views of the funding agency.

Introduction

“Everything is math in the whole world. Everything, everything.”

Tomás, 02/12/07

As a group of Latino/a elementary aged students engaged in a discussion of the mathematical practices of members of their community, Tomás shared this realization with his peers. This seemingly straightforward idea in fact highlights the potential of a mathematics education in which students connect mathematics with their lived realities. The ability to see the mathematics in what is most familiar to them and in the world that surrounds and shapes them is termed the ability to mathematize (Skovsmose, 1990; 2000). A critical understanding of how mathematics shapes and operates in the world is an essential component of a mathematics education for social justice.

Despite the potential for a personally and socially relevant mathematics education, the pervasive and prevailing sentiment of many young Latino/as like Tomás, a trend that often becomes more pronounced over time, is that education is irrelevant to their lives and schools are disconnected from their experiences and communities (Valenzuela, 1999). Latino/a educational attainment as reported in the 2000 US Census indicates that only 52.4 % complete high school and 30.3% complete some college or more, while the national average for high school completion was 80.4% (US Census Bureau). At the same time, the Latino/a population in the United States continues to grow (50% increase from 1990 to 2000 (US Census Bureau)). Statistics on educational attainment and achievement suggest that for students like Tomás, the notion that school is irrelevant has devastating consequences for the growing Latino/a population.

There is potential for a paradigm shift in mathematics education to one in which the primary goal is to empower students to be critical and active participants in their own learning, schools, communities, and in the world around them (e.g.Boaler, 2006; Civil, 1998; Frankenstein, 1983; Gutstein, 2006; Gutstein, Lipman, Hernandez, & de los Reyes, 1997; Skovsmose, 1990, 1994; Tate, 1995). In our current research, we seek to describe a mathematics learning setting for elementary students where the explicit purpose of the education is to engage students in becoming active, critical citizens who use mathematics as a tool to read and write their worlds. This mathematics learning is deeply embedded within authentic contexts of the students' communities, which we argue allows the students to reconceptualize what it means to do and use mathematics. This leads to the possibility of redefining their relationship to the discipline and its relevance and purpose in their lives.

Conceptual Framework

In order to locate our work within past research, we describe the research traditions from which our practice emerges, highlighting areas where we feel our research could contribute to a deeper understanding of teaching mathematics for social justice (Gutstein, 2006; E. E. Turner & Font Strawhun, 2005). This framework for teaching mathematics for social justice builds on a decades-old critical theoretical tradition of education that posits that the purpose of education and schooling is tied to empowerment and liberation from oppression and allows for the potential to enact change (e.g. Frankenstein, 1983; Freire, 1993; Giroux, 1983; McLaren, 1999).

Critical Pedagogy

Freire (1993) describes a libertarian education as one in which, through inquiry, dialogue and praxis, “knowledge emerges only through invention and re-invention, through the restless, impatient, continuing, hopeful inquiry human beings pursue in the world, with the world, and with each other” (p. 72). In this model of education, the teacher and the students are engaged in dialogue as equal members of a community of inquiry. Freire calls for the transformation of the structures of schooling in order to allow students to enact change. Education moves beyond formal schooling and highlights the need to embrace the hybridity of practices (moving away from a school/home dichotomy) and to embed education within community and global contexts that are meaningful to students.

McLaren (1999) extends Freire’s notion of critical pedagogy to a revolutionary pedagogy. He highlights the need for education to develop critical consciousness in students, an element that is central to a framework for teaching mathematics for social justice. He argues for an analysis of social conditions that centralizes class as the dominant force countering active participation in democracy. Inherent in these models for interrogating existing social structures is the location of power. If the belief is that teachers hold power, including mathematical power, in an education system that further marginalizes nondominant students and their communities (Valenzuela, 1999), the education system will continue to reproduce inequity.

Authentic Contexts for Critical Pedagogy

A growing number of researchers argue that education must be grounded in students’ experiences, needs and circumstances in order to be transformative (González, 2005; Valenzuela, 1999, 2002). It is often assumed that curriculum and institutional

structures are neutral, leading to the notion that the blame for disconnect from school lies within the student (Trueba & Bartolomé, 1997; Valenzuela, 1999). In order for schools to be locations of transformation, the development of critical consciousness must be grounded in real contexts and experiences of students. Students must feel that their own experiences are valued and integrated with their formal schooling experiences. This is imperative for nondominant students and communities, who are often marginalized in schools and classrooms (Ladson-Billings, 1995; Valenzuela, 1999).

Critical Mathematics Pedagogy

Several researchers and mathematics educators have explored possibilities and potentials for incorporating critical literacy into mathematics education research and/or learning settings. Skovsmose (1990; 1994; 2000) developed the idea of connecting mathematics and democratic classrooms with the notion of understanding that mathematics is a tool that shapes society in often oppressive ways. He sees mathematics as a critical tool for social transformation and outlines that this can be done through the development of mathemacy: using mathematics as a tool to read and write the world (Skovsmose, 1994). Building on the Freirean (1993) definition of literacy related to empowerment, Skovsmose argues that the development of mathemacy is equally as essential.

Critical Mathematics Pedagogy in Practice

In a more practical application of these ideas, researchers and educators have documented how mathemacy can be developed within social movements (Moses, 2001) and classrooms (Civíl, 1994; Frankenstein, 1983, 1990b; Gutstein, 2006; Gutstein et al., 1997; Gutstein & Peterson, 2005; Tate, 1995; E. E. Turner & Font Strawhun, 2005).

Several researchers have connected mathematics education to larger social struggles for African American high school and adult students in particular (Frankenstein, 1983, 1990a; Moses, 2001). Bob Moses, the noted civil rights activist and educator outlines the importance of incorporating critical mathematical literacy in schools and classrooms, as well as how this is tied to a social movement in his noted “Algebra Project.” Frankenstein (1983; 1990a) has also developed the idea of a critical mathematical literacy curriculum in her work with adults. This work has provided a foundation for the transformative power of using mathematics as a tool to read and write the world.

A culturally relevant approach to teaching mathematics has been developed out of Ladson-Billings’ (1995) theory of culturally relevant pedagogy that is said to address student achievement, affirm students’ cultural identities, and encourage critical perspectives in students. In this framework, power is rooted in the community and in the students rather than with the teacher or researcher. Tate (1995) describes how this can be applied to mathematics education in particular, where a curriculum centered on problem solving connected to real experiences offers the possibility for students to use mathematics as a tool to change society. A theory of culturally relevant pedagogy applied specifically to mathematics has been further developed, focusing on research with Latino students in particular (Gutstein et al., 1997).

Teaching Mathematics for Social Justice

Building on this previous theoretical and empirical research, Gutstein (2006) has developed a comprehensive framework for teaching mathematics for social justice. We draw on this framework in our own work. Gutstein’s (2006) framework involves a focus

on the three Cs's: Community, Critical and Classical knowledge, each of which is essential to a potentially empowering and transformative mathematics education.

Gutstein's work also highlights some of the challenges educators face while engaging in critical pedagogy and attempting to incorporate all three knowledge bases. However, there is clearly a need for more research that further explores how this can be done and what it might look like.

Community knowledge is related to the funds of knowledge (including informal mathematical knowledge and critical knowledge) that students and communities have. Gutstein (2006) defines community knowledge as involving "how people understand their lives, their communities, power, relationships, and their society" (p 110). His framework incorporates previously developed ideas of building on student's funds of knowledge (Civíl, 1994; González, 2005; González, Moll, & Amanti, 1995) and reconceptualizing students' experiences as being a basis for empowerment rather than as a deficit. Classroom instruction should honor, value and build upon this knowledge, allowing it to generate issues or questions that might be explored mathematically.

Critical knowledge includes the development of a sociopolitical and critical consciousness in students. Gutstein (2006) describes critical knowledge as "knowledge about why things are the ways they are and about the historical, economical, political, and cultural roots of various social phenomena" (p 110). This includes the development of knowledge about mathematics as a tool to read the world, as well as critical knowledge in general, which moves beyond mathematics to an ability of students to critique the world around them. Students must be able to understand power relationships and the sociopolitical contexts of their lives and communities.

Classical knowledge refers not only to the specific skills and competencies typically seen in mathematics classrooms, but also the ability to understand that this equates to mathematical power. Apple (1992) and Skovsmose (1994; 2000) describe the unique position of mathematical knowledge in relation to power and how it organizes society in ways that perpetuate inequity. Therefore, classical knowledge in itself is not enough and can serve to reproduce the status quo, while an understanding of these power structures allows for this knowledge to be utilized in transformative ways.

This review of research related to critical pedagogy and its application in the realm of mathematics education indicates directions for future research. Previous research has focused primarily on work with adults or high school students in which problems are posed for students, and not necessarily embedded within authentic community contexts. With our work, we seek to explore the tensions and possibilities in teaching mathematics for social justice with young students in the process of posing problems within authentic community contexts. Through descriptive cases of three mathematics projects, we will highlight how a social justice mathematics pedagogy grounded in authentic community contexts offers students an opportunity to reconceptualize community practices, mathematics and its role in their lives. We will describe our research setting and methods, outline the three cases, focusing on tensions and possibilities, and conclude with implications for further research and praxis.

Setting

Our research is based in an after-school mathematics club (Math Club) that is part of the Center for the Mathematics Education of Latinos/as (CEMELA), an interdisciplinary, multi-university consortium focused on the research and practice of the

teaching and learning of mathematics with Latino students in the United States (www.math.arizona.edu/~cemela). The Math Club takes place in a primarily Mexican/Mexican-American neighborhood of a Southwestern U.S. border city. Many of the Latino residents of this neighborhood are recent immigrants from Mexico, while others have lived here for generations. The neighborhood is characterized by its similarities to Mexico, containing small bungalow-style houses, signs in Spanish, and local businesses selling Mexican products, reflecting the history of the area as being a part of Mexico (González, 2001).

The Math Club takes place at Agave¹ Elementary School, during its regular after-school program. The school has approximately 300 students and a warm and welcoming environment, with walls decorated with displays of student work, photographs and information about school programs. The student body is primarily Latino/a (90%), as are many of the teachers, staff and administrators. At Agave, over 95% of the students qualify for free or reduced lunch and 26% of the students are classified as English Language Learners (ELL) (District Statistics). The school has been affected by recent state legislation (Proposition 203, passed in November 2000) concerning bilingual education calling for ELL students to be placed in Structured English Immersion (SEI) classrooms rather than bilingual classrooms. The result is that students that attend the Math Club who are talented bilinguals or predominant Spanish speakers are limited in their ability to draw on this knowledge in their classrooms.

The Math Club meets for two hours after school, every Monday and Tuesday. The current participants are approximately twenty students, four undergraduate facilitators

¹ All names are pseudonyms

and five participant researchers. The number of students present on a given day is typically between twelve and fifteen, and participation is completely voluntary. Students come from third through sixth grade classrooms, though most are fourth-graders. The mathematical skills of the students vary, as do their beliefs about themselves as learners: some are in the Math Club because they like mathematics, and some are there because they feel they are not good at it and need to improve.

The students are all Latino/a (some part-Native American), mostly Spanish-English bilinguals with varying levels of proficiency in each language. Most of the undergraduate facilitators are bilingual or speak Spanish well enough to work with the students and three of the participant researchers are bilingual. One intention of the Math Club is to provide a bilingual environment that encourages students to draw on their everyday and academic knowledge and skills, including language, and share them collectively.

Math Club is a setting in which participants come together to create a learning space that is transformative for all those involved; everyone's voice is heard and valued; and students' experiences and lives outside of school are incorporated into their mathematics learning. One of the ways that this is accomplished is by having students take an active part in creating content. Sometimes an idea for a project will come from the students and we will create a project based on this interest, as was the case with the immigration and park projects described later in the paper. More frequently, the broad context for a project comes from us, but the students choose the focus.

To support our focus on teaching mathematics for social justice, in the Math Club we strive to create a space where controversial topics can be freely discussed (Gutstein,

2006). This entails that students feel comfortable expressing their opinions or sharing personal stories, and that they listen to and respect one another. Such a space needs to be developed over time: we still periodically need to remind the students of the norms they have set themselves and occasionally we have whole-group discussions where students share their concerns and compliments about the Math Club and their peers. Sometimes this means “sacrificing” time that would otherwise be spent doing mathematics, but we find it necessary for creating the type of setting we wish Math Club to be.

Each Math Club session is structured as follows: we begin with a warm-up problem, which is usually collaborative in nature. Next, students have choice time, during which they play mathematical and strategy games either in the classroom or computer lab. The last part of each day is spent working on community-based projects.

Methods, Data Collection and Analysis

Methodology

Heeding the call of several recent mathematics education researchers (Gutiérrez, 2002a, 2002b; Valero, 2004; Vithal, 2000), we ground our research in the belief that it must be critical. Consistent with the principles of critical ethnography (Foley, 2002; Trueba & Bartolomé, 2000) our research aims to describe issues of power and oppression, and offer hope for change through a critical, yet transformative perspective. Trueba and McLaren (2000) describe the crucial element of critical ethnography as being, “to transform society via conscientization and social change” (p.39). This methodology highlights the relationship between research and praxis, which we define as the commitment to activism and the struggle for universal human rights (Freire, 1993). Critical ethnographic methods allow us to capture the voices of students in our

description of a potentially transformative educational experience. Through our integration of research and praxis, we seek to produce counternarratives to a deficit perspective of Latino/a students as well to describe possibilities for a critical mathematics education.

Valero (2004) contends that critical mathematics education research must ensure that the location of power is not solely with the researcher. In our own research, we address issues of power by offering opportunities for participants in an after-school mathematics club to express their voice, demonstrate their agency, and engage in a process of coming to use mathematics as a tool for change. Valero (2004) also notes that critical mathematics education research, which comes from a socio-political perspective, must include an analysis of power relationships in local and broader contexts. In our research we seek to offer the opportunity for Latino/a students to critique dominant views about themselves as mathematics learners and about the practices of their community.

Our research is part of a larger study (in our third year) of an after-school mathematics club in which the authors are participant researchers. We utilize critical ethnographic methods in seeking to understand the intersections of language, culture, social justice pedagogy and mathematics for Latino/a students. For the purpose of this paper, we describe cases of projects that were designed to help students define what is important to them and their communities and engage in a process of reading and writing their worlds.

Data Collection and Analysis

As participant researchers in a larger study of students in the after-school program, we have developed detailed, descriptive cases of our students as mathematics

learners over time and across settings. We collect field notes and videotape after-school sessions, conduct regular classroom observations, interview students four times a year, and conduct home visits up to two times a year. Based on a grounded theory approach to analysis (Strauss, 1987), we collectively generated emerging codes related to our research questions: student learning, participation, language, relationships, etc. and began to look for patterns. We then refined these codes and generated themes agreed upon by the research team based on emerging theoretical categories (Maxwell, 2005). These themes then formed the basis for generating cases of students as mathematics learners.

For the purposes of this paper, we offer a rich description of how students' experiences with three projects inform a pedagogy of teaching mathematics for social justice. We collectively reviewed all projects that students participated in over a two year period and selected three cases that exemplify attempts to integrate the three knowledge bases in teaching mathematics for social justice: community, critical, and classical mathematical knowledge. In the sections that follow, we describe each of the projects in greater depth. Each case begins with an overview that includes the history of the project, and a general description of the activities involved. We then draw on specific episodes of students' participation to highlight the integration of multiple knowledge bases, including any tensions that emerged and how those tensions were negotiated. Following the three cases, we conclude the paper with a discussion of cross cutting themes.

The Immigration Project

On December 16th, 2005 a law was passed in the United States House of Representatives and introduced to the Senate that would criminalize illegal immigrants living in the U.S. (H.R. 4437). In the months following the introduction of this

legislation, Latino and non-Latino supporters mobilized in great numbers across the United States.² In the city where the Math Club takes place, high school students took to the streets to demonstrate their disagreement with the legislation. Most of the students in the Math Club are first- or second-generation immigrants or have relatives who are immigrants, and thus felt personally affected by the law and energized by the local movements. Several students and their families participated in local rallies and marches. These events were the catalyst to our immigration project, in which students used mathematics to investigate this critical national issue affecting their community. These events shifted the student's orientation to critical knowledge and their sense of agency, allowing for an ideal context for a project integrating all three knowledge bases. Within the context of the immigration project, we will describe an episode involving one student's mathematical investigation and the group discussions that it evoked, highlighting how the knowledge bases were integrated as well as tensions and possibilities that emerged.

Previous to the start of this project, we had engaged the students in discussions about social activism and their role in changing problems in their community or in society. Some students claimed, "It is not possible to change anything." In response, one of the facilitators attempted to challenge the students' lack of a sense of agency by showing them examples of young activists. One of the examples she gave was of a young man who had fought against a multinational company that uses child labor. The students were shocked by what they saw and were soon immersed in a rich discussion of this example. Some said that we should write a letter to the president to alert him of the

² See CNN news. For more information about the protests:
http://en.wikipedia.org/wiki/2006_United_States_immigration_reform_protests

inhumanity of sweatshops, although this enthusiasm was short-lived. This was the first time students had demonstrated that they felt they had the power to change, yet it was not about an issue connected directly to their community. We wanted to embed their mathematical investigation in an issue relevant to their community to ensure inclusion of community knowledge.

The events of March/April 2006 changed how we envisioned a project that involved an integration of critical, community and mathematical knowledge. Faced with an issue that had an immediate bearing on their lives, the students were engaged and critical of the federal government's proposed legislation to criminalize undocumented immigrants living in the U.S. They began to see themselves as individuals who could be agents of change in their own lives, and who could use mathematics to develop a critical understanding of a situation that was personally and socially important.

During an initial whole-group discussion about immigration, we encouraged students to think about possible mathematical problems they could pose related to the issue. A rich discussion ensued in which critical and community knowledge (intertwined) emerged. Students also expressed concerns about the fate of undocumented family members or even themselves, asking, "Will my Nana be taken away on Monday?" and "Will they find my Mom's boyfriend and send him back?" Veronica and Patri thought it would be important to capture their community's stance on this National issue and came up with the idea of creating a survey about community members' view on immigration. They generated five questions related to the legislation and surveyed their family members that evening.³ Upon returning to the Math Club the following day, they

³ Survey questions were: (1) Do you want the immigrant law to pass; (2) Are you an immigrant; (3) Do you think the law will pass; (4) Are you going to be a part of the strike; and (5) Why or why not?

presented their results and worked with the group to organize their data. In this instance, mathematics gave the students an opportunity to explore their community's perspective and allowed them to take an active role in discussing the topic of immigration.

During the presentation of the survey Veronica and Patri collaborated with their classmates to quantify the data. They created a table and calculated fractions and percentages for each response. In describing how they had organized their survey responses, Veronica and Patri brought up issues such as anonymity, "My dad didn't want to put his name on this," and language, "My tía, she put this for my nana. She put, 'put minutemen to work a real job.' Because she talks in Spanish and nobody's going to understand her writing." In the process of engaging in the mathematical practice of collecting and organizing data, issues related to what it means to be an undocumented immigrant arose. The students indicated that some family members did not want their names to be on the paper for fear of reprisal and that their grandma had their tía write for her because she was afraid the response wouldn't be understood. In this example, students drew on their community knowledge about immigration to negotiate the complexities involved in collecting data about a sensitive, yet critical issue.

Shortly after this exchange, the facilitator attempted to steer the conversation to a more mathematical discussion of how to represent data. However, the girls decided they wanted to extend the survey to their class members, which prompted an engaging discussion about what it means to be an immigrant.

Facilitator: A lot of times people use percentages to analyze and talk about data.

Verónica: Miss, can I do it to them, miss?

Facilitator: What?

Patri: Can I do these to them? [*Indicating she wanted to ask the survey questions to the members of the Math Club.*]

Facilitator: Oh you wanna ask-, sure.

Verónica: Let's ask them miss.

(...)

Patri: Okay. Who's an immigrant? Who's from Mexico?

Jackie (facilitator): Do you have to be from Mexico to be an immigrant?

Ksenija (facilitator): I'm an immigrant but I'm not from Mexico

(...)

Ksenija: What is an immigrant though? That was the question.

Are you an immigrant. Right?

Patri: Tell Verónica, I don't know.

Ksenija: That was your question Verónica, yes?

Veronica: Ya.

Ksenija: So if you were born here are you an immigrant?

Jacinta: No.

Ksenija: Right, so we're asking how many people were born elsewhere.

Jacinta: Like from Mexico, Brazil. (4/11/2006).

Some students became very animated and shouted out where they were born (mostly Mexico). This particular interaction was not mathematically rich, but in the process of organizing the data, it became necessary to negotiate the meaning of an immigrant as represented in the survey. We see this example as important because it highlights how students' mathematical activity generated a critical discussion related to their community knowledge of what it means to be an immigrant. Students were actively engaging in defining what an immigrant means in this personally meaningful context.

Although this project allowed students to draw on community knowledge to use mathematics critically and learn how to make sense of mathematical situations (such as using tables to organize information, or interpreting percentages), it is also true that tensions arose in our attempts to integrate the three knowledge bases. Sometimes the students' discussions and the need to define "immigrant" for example, pushed the

mathematical discussions into the background. In the end, we were unable to spend as much time discussing representation of data as much as we would have liked.

To connect the three kinds of knowledge that Gutstein (2006) points out was not easy (sometimes because the subject was so political and complex, students were more engaged in critical discussions rather than dialogues around classical mathematics). Despite this, there were some interesting examples throughout the case where we can see the students making connections between knowledge bases because of the relevancy of the context to their lives (e.g., interpreting and organizing data related to immigration). This was the transformative contribution of this project: working in an authentic critical and community context facilitated connections between the three kinds of knowledge bases. This case exemplifies how a critical community issue prompted students to find ways to utilize mathematics as a tool to read and write their worlds.

Park Case

The “Park Case” describes students’ participation in a multi-week project focused on investigating a recently constructed neighborhood park. Several weeks before the official dedication ceremony to celebrate the opening of the park – the only one in the community – the playground structure burned down. The fire occurred during our after-school Math Club, and was clearly visible from the school grounds. A number of students visited the site after fire fighters had extinguished the flames. As they contemplated the remnants of a place where friends and family had come to play, they commented on the importance of the park in their community, and their sadness that it had burned down.

When students returned to Math Club the following day, the park was the subject of much conversation. Students shared ideas about what had happened, and posed a series

of questions they wanted to investigate. They were interested in how much it cost to build the park and how long it would take to rebuild it. They also wanted to know whether they could “design a *new* park” for the community. Given students’ genuine interest in the park, and more specifically, their desire to participate in redesigning it, we made the park the focus of an extended investigation. We envisioned the park project as having the unique potential to integrate rigorous mathematical knowledge, community knowledge and experiences, as well as critical knowledge about participation in community design and planning.

Over a six week period, students engaged in a variety of “park-related” activities. They visited the site and took pictures, created diagrams of the layout, measured the perimeter of the park and calculated its area, and then used these measurements to construct a to-scale diagram. At certain points it became clear that in order to proceed, students needed access to mathematical understandings and skills that not all students had previously developed. We helped students to develop these important mathematical ideas both in the context of park-related activities and through related tasks designed to build understanding that could then be applied to the ongoing investigation of the park.

In what follows, we use several episodes from “the park project” to illustrate the integration of mathematical, community, and critical knowledge that emerged. We highlight tensions related to this integration and describe how they were negotiated.

As previously mentioned, students expressed a strong desire to participate in redesigning the community park. They shared specific ideas such as incorporating a basketball court, bathrooms, a water fountain, and “a ramada so that the people can sit and have parties there.” These were ideas that were grounded in their own experience

visiting the park before it burned down, and in their sensibility towards the needs of community members. As they thought about how they might represent their designs on paper, students encountered the need to understand the concept of scale. For example, some students initially thought that they could draw the outline of the park on grid paper, representing a distance of one meter in the park with the length of one square on the grid. While this was certainly a valid scale, given the constraints of the grid paper (which was not 60 squares long), it was not the most viable solution. Students then had opportunities to work in small groups to figure out how to represent the dimensions of the park on the grid paper they were given. David and Katia decided “to cut it in 3s,” meaning that the length of a square on the grid paper represented a length of 3 meters in the actual park. Other groups decided upon different scales, having the length of one square represent a distance of 4 meters or 5 meters in the park.

After students shared the scales that they generated, they discussed which scale might “work better” for their designs. While a few students recognized that the “one square is 3 meters” scale would be preferable because each square represented a smaller amount of space and therefore objects in the park could be represented more easily, many students voted that “3 meters is better” because they believed that a park drawn using this scale would actually have more space. For example, Felipe argued that “3 was better” because “if you use the 4 [the length of a square represents a distance of 4 meters] it might not have a lot of trees and bushes and with the three [scale] you could.” The use of different scales to represent the same object was understandably a difficult concept for many of the students, especially since their previous experience with proportions and scales was limited. To make sense of this unfamiliar concept, many students attempted to

draw on their own knowledge and experiences: the scale that made the park “look bigger” on paper was better because it would imply having more space to play. We addressed these misconceptions during the following session; however some students remained unconvinced that a larger to-scale drawing did not necessarily mean a larger park.

We see this episode as powerful because it illustrates the multiple knowledge bases that students drew upon and attempted to integrate in their efforts to re-design the community park. Their experiences playing in the park and their intimate knowledge about the community and the needs of its members positioned them as experts in the design process. They embodied a set of knowledge and sensibilities that city planners who came from outside the community did not possess. The task of redesigning the park not only provided students opportunities to draw on this knowledge, but also explicitly positioned their community-based knowledge as valuable and critical to the success of the project. Also evident in this episode is the rich mathematical content that students explored as they struggled to find ways to accurately represent their designs on paper.

Additionally, this episode highlights a set of tensions that emerged. For example, there were several instances when the mathematics students needed to proceed in the project (e.g., the concept of scale) was beyond their conceptual reach. This prompted us to “take a step back” and explore the mathematical ideas in greater depth – a response which students did not always experience as connected to the larger, more authentic task. Similarly, there were situations when the mathematical reality of the context (e.g., the very irregular dimensions of the park) created a level of complexity that was, in some cases, too challenging for elementary students. As a result, some of the authenticity of the data was sacrificed (e.g., we approximated the perimeter of the park with a rectangle) in

an effort to design mathematical tasks that were more accessible to students. Another tension evident in this episode is related to how students drew upon personal experiences and ideas about the park in their efforts to make sense of a challenging mathematical idea – the use of different scales to represent the same object. While in many other instances students drew on personal and community knowledge to support their mathematical activity, this was one instance when students’ ideas and experiences almost seemed to obscure the mathematics: their focus on the need for a larger park, coupled with a mathematical concept that was already quite challenging, made it difficult for them to think about how diagrams of different sizes could actually represent the same park.

Shortly after the Math Club session described above, a conversation with a City Council member revealed that although the city had initially expressed interest in students’ ideas, redesigning the park was not part of their rebuilding plan. Instead, they intended to purchase and reinstall the exact same play equipment and other structures that had existed in the original park. This caused a marked shift in the focus of the project. During one conversation Tomás poignantly asked, “Is it true that they [the city] put some of our ideas to make the park? ... Like *us* Math Club kids, [we] put some of *our* ideas to like make the park?” When one of the facilitators explained the city's plan to simply rebuild the same park, Tomás replied, “The *same* park!” with disappointment. Although students might have continued with the initial plan for the project – to submit designs to members of the City Council – when they learned the city would not genuinely consider their ideas, much of the authenticity of the project was lost.

At this point, a few students went on to finish their designs (Tomás not included), but many others seemed to lose interest in the project. Our desire to be responsive to

students' interests (or lack thereof), coupled with our commitment to the project, led us to reflect on other comments that students had shared about the park. We noted an enduring desire for “a bigger park” that as Tomás noted, would “have more space to play so more kids could come.” As a result, we posed the following question: “Given that this is the only park in the community, is it big enough?” We provided students with census data of the number of adults and children living in the neighborhood, as well as a neighborhood map. Interestingly, students interpreted this question in very different ways.

For example, Carlos and Julian focused on whether or not the number of swings was sufficient. They estimated that half the children in the neighborhood might come to the park on a given Saturday afternoon (the most popular time, based on their experience), and then figured that if each child wanted to swing for approximately 10 minutes, it would take over 4 hours for all the children to have a turn. This, they concluded, was “a *long* time.” We find this episode interesting because it demonstrates how students drew upon personal knowledge and experience to reframe the question of whether or not the park was “big enough” to one that was more meaningful to them: “Does the park have enough swings?” Next, Carlos and Julian drew upon mathematics as a tool to critically evaluate the situation. They estimated park attendance as well as “swinging time” and then used their estimates to model how long it would take a given numbers of students to each have a turn. This example demonstrates how students' personal and community experiences shape the mathematical questions that they pose, and how their mathematical investigation informs their critical analysis of the situation.

Throughout the project we had to make numerous adjustments to ensure that all three knowledge bases were present. Sometimes this meant making the community

knowledge of the students secondary to the mathematical content we thought necessary; sometimes it meant modifying the mathematical content so that students could better utilize the unique knowledge they had of the context. Finally, due to circumstances that were beyond our control, we lost the opportunity to build on students' critical knowledge (submitting a proposal for a new park to the City Council) and had to engage in a slightly less authentic exploration instead (answering if the park was big enough for all children in the neighborhood). While many students were genuinely engaged in evaluating the park's space, it did not seem to have the same "pull" for students that redesigning the park had. Even so, when students later reflected on their experiences, they found benefit in the project, and some even maintained that they felt that their work contributed to the rebuilding efforts.

Low Rider Case

During February and March of this year, we conducted a community-based project in which students explored and investigated the mathematical and related practices of local contexts. Students created digital stories⁴ based on this experience, highlighting how they made sense of and engaged in these mathematical practices. As we began this project, it became clear that the digital stories could offer a way for students to create counter-narratives to the dominant deficit perspective of their urban Latino/a community as well as to document and highlight the potential of Latino/a youth engaging in critical mathemacy.

⁴ Digital Stories are multimodal, multimedia movies that include narrated voice recordings, photographs and video images, and background music (Hull & Nelson, 2005).

The contexts were chosen from a range of community locations brainstormed by students, primarily based on the work of their family members. Several parents did visit the Math Club or were interviewed at home about their practices to further the students' understanding. Teams consisting of three or four students, a participant researcher, and in some cases an undergraduate facilitator investigated four different community contexts: a bakery/donut shop, a *dulcería* (candy store) and piñata shop, a custom auto shop (all three small businesses are family-owned and operated), and the local fire station. For the purposes of this case, we will focus our description and analysis on the context of the custom auto shop, an important and valued form of artistic expression and local identity in this community. This practice is in fact part of a larger global context of low rider cars and custom autos found in many urban areas across the United States and beyond.

After an initial visit to identify the practices at each of the sites, the groups brainstormed the kind of data they needed to collect to better understand the practices. We returned to the settings to take photos and video recordings, interview community members, observe practices and to collect measurements or other mathematical data. After this visit, students engaged in problem posing and/or solving related to the context. Finally, the students created a digital story documenting the experience. Within the context of the low rider custom auto shop group, we will describe two episodes that highlight the knowledge bases as they emerged in the project as well as tensions and possibilities offered by social justice mathematics pedagogy.

Because the practice of customizing cars or making low riders is a source of pride for many in this community, students had a great deal of prior knowledge about the context and were subsequently positioned as experts. In particular, Elias demonstrated

engagement and enthusiasm for understanding the practices in depth. During a discussion with the owner of the auto shop, Elias shared his knowledge related to painting customized autos, seeking to validate and refine this community knowledge:

Elias: Don't you use tape to make the designs and then you paint it over it?

Dan: Right.

Elias: Or do you guys use pla- another piece of plastic and just put it- what do you guys do?

Dan: We need to use a- we use a ruler and we measure the designs cause we want 'em to be the same size. So we are always measuring and then we have to put tape and then we have to sand it and then we have to spray it, and then we take off the paper and then we do another design and spray it and take it off. (02/06/07)

Other students asked questions about the process of transferring designs to cars in order to understand this procedure in depth. The auto shop owner refined their understanding and explained the mathematics behind this process:

Gisselle: ¿Cuando hacen el diseño en el papel, como saben de que tamaño va a ser en el carro? */When they do the design on the paper, how do they know what size it will be on the car?*

Dan: Lo que hacemos es medimos la área donde va a estar el diseño y luego de las medidas esas, hacemos el diseño para que le queda al carro. Primero medimos el carro y que tan grande puede ser el diseño. */What we do is that we measure the area where the design will be and then from those measurements, we do the design so that it will fit on the car. First we measure the car and how big the design can be.* (02/06/07)

This episode illustrates how an exchange of community knowledge positions students and community members as experts about practices that involve classical mathematics. The mathematics involved in the practices of this authentic community context became more explicit for Elias. The positioning of Elias as an expert was essential in how we perceived of the project as also developing critical knowledge, because he was able to understand how mathematics was involved in practices important to him and that are typically undervalued and seen as non-mathematical. As illustrated by Elias's

engagement with the project and the dialogue that occurred at the low rider auto shop, the placement of this work within authentic community contexts created the potential for the integration of the three C's.

One of the artists at the auto shop explained that they often use tools such as copy machines, rather than their own calculations to enlarge a design to create a stencil:

It's actually really simple, they start sometimes with a small design and what they'll do is they'll blow it- they'll go to Kinko's..... and Kinko's will do a lot of things for you and they will blow it up as far as for artists when they're painting and stuff like that. They'll blow up the whole image much, much bigger. (2/13/07)

A tension that this episode highlights is ensuring rich mathematical knowledge development. Community members often didn't articulate the mathematics involved in a practice beyond the level of naming the mathematics used in a process, such as "we measure the hood of the car" or "they'll go to Kinko's" Often this was because the mathematical part of the procedure was done with tools such as a machine or a computer. We found that the more complex mathematics was understood but often implicit in practices described or done by the community members. In order to negotiate this tension, we needed to explore these practices and articulate the mathematics ourselves in order to ensure that students could engage in rich mathematics.

Elias was motivated to engage in mathematics as he replicated the practices of the low rider artists in this second episode. After designing the artwork for the hood of a low rider, he attempted to transfer his drawing to a larger piece of paper, similar to the transfer process low rider artists would use to enlarge a freehand drawing to create a stencil. In this episode, Elias is being pushed by the facilitator to explain his thought

process as he begins to make sense of how proportional reasoning might apply in this context:

Elias: You know you have to measure.
 Maura: Measure what?
 Elias: What's seven plus seven?
 Maura: You know, don't you?
 Elias: 14, so I need another ruler. [14 inches only reaches about $\frac{2}{3}$ of the paper's width]
 Maura: Show me what you are measuring?
 Elias: Check this out. What's three times seven?
 Maura: Why are you- what's- why are you asking about those numbers? Where do those numbers come from?
 Elias: Three times- what is three times seven? Just-miss, what is it?
 Maura: 21
 Elias: It has to be 21. [lining up two rulers]
 Maura: Oh, what was seven? Elias, did this measure seven inches [pointing to the width of his drawing]?
 Elias: Yeah.
 Maura: So you're doing- you're saying it's going to be three times bigger?
 Elias: Yup. So this is how long it's supposed to be.
 [Elias is visually estimating that making his design three times longer would almost fill the paper.]

Despite the fact that the artists might go to a photocopy center and have their original drawing blown up to fit the hood, they ultimately understand the underlying mathematical process. The artists, and Elias in this case, understand how mathematics is a tool that operates in everyday practices, which we believe is essential to thinking about mathematics as a tool to read and write the world. Therefore, although Elias is engaged in developing classical knowledge to make sense of and replicate this artistic process, it is embedded within an authentic community context where community knowledge was vital to this understanding. In addition, understanding the complexity of the work of low rider artists serves to counters a dominant deficit perspective of this community practice.

Elias's ability to mathematize this process in a way that made sense to him allowed him to express mathemacy: he is reading and writing his world with the tool of

mathematics. Looking at the larger context of how his community and these practices are perceived from outside, as well as how Latino students are often perceived in dominant discourse, the critical nature of his ability to mathematize emerges.

These episodes illustrate the complex nature of social justice mathematics and the integration of the three knowledge bases as outlined by Gutstein (2006) as well as some tensions and possibilities that emerge. The rich and complex mathematics underlying these community practices sometimes needed to be made explicit by facilitators to ensure the development of classical knowledge. Because Elias was positioned as an expert, his classical and community knowledge is intertwined within a context where his process of mathematizing and engaging in authentic practices is embedded within a broader critical perspective on his community and identity as a Latino.

Cross-Cutting Themes

In the sections that follow, we discuss tensions that arose across the three cases presented in this paper. We describe how these tensions were negotiated, and then present a set of “possibilities for transformation” that were evident in each of the cases.

Common Tensions

We began this paper with Tomás’s comment that “*Everything is math in the whole world. Everything, everything.*” As insightful as this comment is, we noted a number of tensions related to drawing on authentic, real-world contexts to generate mathematical activity. To begin, the mathematical ideas that shape familiar contexts and practices are often difficult to recognize (Díez-Palomar, 2004; Niss, 1995). In our work, there were instances when the mathematics was so implicit in the day-to-day practices of the setting (e.g., custom auto shop artists who sent drawings to a copy shop to be enlarged instead of

using proportional reasoning to enlarge the drawings themselves) that although the setting had the *potential* to generate rich mathematical activity, substantial work was required to make the mathematics more explicit. In such instances, we found ourselves repeatedly seeking out opportunities to call attention to mathematical ideas.

Even when the mathematics was easily recognizable, there was no guarantee that it would be accessible to elementary age students. For example, students' interest in designing a new community park generated a real need for rigorous mathematics, but the mathematics that was needed was beyond some students' conceptual reach. When this happened, we frequently "took a step back" to examine a particular mathematical concept in greater depth. Moving between highly contextualized problems and related, but sometimes de-contextualized tasks was not entirely unproblematic. It was not always clear to students how the "more mathematical" work related to their ongoing investigation in the community, and thus it became imperative for facilitators to help students make those connections more explicit.

Additionally, a community context may be rich in mathematical connections, but those connections may or may not be relevant to the aspect of the situation that is of greatest interest to students (Stevens, 2000; E. Turner, 2003). For example, during the immigration project students were highly engaged in a critical, but largely un-mathematical discussion about the meaning of "who is an immigrant," while our attempt to push the mathematics by using fractions and percentages to summarize survey results was met with some disinterest. In such instances, we found it important to honor students' need to share their questions and stories and to collectively negotiate understanding about issues that were both personally and socially relevant. Additionally,

we came to recognize that in any one activity or project, a balanced integration of critical, community and mathematical knowledge was often impossible. Although we framed each of the knowledge bases as essential to our ongoing work in the Math Club, we at the same time understood that certain projects would inevitably be “more mathematical” or “more critical” than others.

Another tension that cut across the cases was related to supporting students’ mathematical understanding when connections to the discipline emerged rather organically, and sometimes even unexpectedly. Investigating authentic community contexts is inherently “messy,” as it is not always possible to predict which aspects of the situation will be most compelling to students, nor what kinds of problems (mathematical or non-mathematical) they will pose. For instance, while investigating how low-rider artists enlarge a drawing to fit on the hood of a car is clearly mathematical, students might just as easily have become interested in the financial aspects of creating and selling low-ride vehicles. While both questions would lend themselves to rich mathematics, the mathematics involved would be quite different. Creating opportunities for students to investigate authentic contexts in ways that are personally and socially relevant necessarily involves mathematical activity that will both emerge as the project unfolds, and diverge as groups of students assume increasing ownership and decide to explore different questions. Given that our work was situated in an after-school setting, and that we were not expected to follow a standard curriculum, we had substantial freedom to explore a range of mathematical ideas. This freedom, combined with the fact that we had multiple adults that could facilitate small group work enhanced our ability to follow students’ interests and intentions, even when those interests diverged.

A final tension was related to the extent to which each of the cases drew upon and supported the development of critical knowledge about the local and global community. In the immigration project, the incorporation of critical knowledge seemed almost effortless – students openly critiqued our nation’s treatment of immigrants, and posed challenging questions about the motives behind current and pending legislation. They spoke about the importance of community activism and the value of working in solidarity with others. While students seemed to drive the explicitly critical focus of this particular project, this was not the case in the other two investigations. Instead, we found ourselves subtly, and sometimes not so subtly encouraging students to examine the projects more critically (e.g., *We* posed the question about whether or not the park was big enough for the community; *We* asked students to reflect on how society as whole viewed low-rider related work). We feel that this contrast raises an important set of issues. We suspect that students’ active and critical engagement in the immigration projects was not only a reflection of the importance of the issue in their own lives, and the lives of those they cared most about, but also of the prominence of the issue in the local and national media. While students were clearly disturbed that their neighborhood park had burned down, it did not seem to be an issue that impacted students as personally, or as deeply, as that of legislation that had the potential to criminalize all undocumented immigrants. Similarly, while students were aware of deficit-based perceptions about their community, the need to produce counter-narratives that more positively and accurately reflected local practices (e.g., the practices of the custom auto shop) may not have been as compelling to students as the need to investigate legislation that had the potential to separate families. This

contrast highlights the potential of contexts that have a high degree of personal and social relevance as entry points to critical engagement and awareness for young students.

Transformative Dimensions of the Projects

While the previous section focused on tensions related to teaching mathematics for social justice through the integration of critical, community, and mathematical knowledge, in this section we highlight some of the transformative dimensions (Flecha & Gómez, 2004) of the cases discussed in this paper. To begin, we highlight the power of authentic community contexts to both engage students and support their learning. First, grounding our work in contexts familiar to students positioned them and other members of the community as experts who had unique experiences, understandings, and sensibilities to share. Unlike traditional school mathematics instruction which may marginalize students' community-based experiences, or at best frame such experience as irrelevant to classroom activity, the projects discussed here aimed to privilege students' out-of-school knowledge and as much as possible allow students' experiences to shape the focus of a particular investigation. For example, students drew on their own experiences to reframe a question about whether or not the park was big enough to one that was more meaningful to themselves and members of the community (e.g., "Does the park have enough swings?").

Grounding our work in community contexts also highlighted how situations that are inherently relevant and engaging for students can be used to generate an authentic need for rigorous mathematics. We see this as important because instead of introducing mathematical ideas in ways that are disconnected from students' experiences (something that is all too common in traditional school mathematics), students' interests and

intentions served as an entry point to their mathematical activity. For example, in the immigration project students' desire to talk to community members about their views on immigration related legislation created a genuine reason for students to collect and organize data, and later present that data to their peers. During the custom-auto shop project, students' interest in low-rider art resulted in an authentic need to understand concepts of scale and proportion. In each of these examples, students had opportunities to see how mathematics could be used as a tool to investigate situations that were of personal and social importance. We argue that such opportunities have the potential to help students redefine their *understanding of* and their *relationship to* the discipline and better appreciate the relevance and value of mathematics in their lives.

Finally, centering our work in authentic community contexts made it possible for students to see that their ideas could contribute to and potentially impact situations in the community. For example, creating digital stories that highlighted the mathematical practices of low-rider artists positioned students as producers of knowledge that had the potential to counter deficit-based perspectives of their community. Additionally, although the city ultimately did not consider students' designs for rebuilding the park, students came to understand that such a process was possible, and that at least in principle (and sometimes only in principle), their ideas and experiences mattered. Also important is that students' involvement in the park project meant that they were informed about decisions made by the City Council, which positioned them as experts who could share their knowledge with other members of the community. Collectively, the three projects created opportunities for students to leverage what they learned and experienced as tools to help them better understand and participate in their own community.

Conclusions

In conclusion, the descriptive cases in this paper offer a unique perspective on the possibilities offered by engaging in social justice pedagogy with Latino/a students. We describe Latino/a students engaging in mathemacy as they explore authentic community contexts. This description can serve to counter deficit perspectives of Latino/a student academic achievement and Latino/a communities in general. The work has implications for future work on how to conceptualize social justice pedagogy in elementary school classrooms. Particularly useful would be to engage in dialogue with teachers about the application of this work in classrooms.

As we described the tensions and possibilities encountered in integrating the three knowledge bases, it is evident that this analysis cannot be done without a consideration of a larger whole that this framework is a part of. Equally important to integrating the three C's is building caring and political relationships with students, creating a safe environment, paying close attention to, and honoring and validating student interests and concerns. Important to engaging in critical mathematics research is the recognition that this all takes time and is very much connected to a local context that researchers are often not a part of. We caution that further research will likely look extremely different based on the dynamic nature of relationships, local context and concerns.

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