CHILDREN AND ADULTS TALKING AND DOING MATHEMATICS: A STUDY OF AN AFTER-SCHOOL MATH CLUB

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This paper outlines examples of children learning mathematics in a bilingual and culturally inclusive environment utilizing the lens of student identity as a way to understand the intersection of multiple factors affecting their learning. The research is situated in an after-school setting located in a majority Latino/a school. Several studies highlight the importance of community knowledge, situating it on the same level as academic knowledge. Our findings indicate that the inclusion of community knowledge and use of home language are elements that mediate mathematics learning, particularly in the context of social justice mathematics. The study has implications for teachers who wish to create more inclusive and potentially transformative learning environments for all students.

Objectives

Schools in the United States are increasingly becoming locations where children from different cultures of origin and backgrounds come together. These multicultural contexts raise important challenges to professionals who work in educational settings, particularly in light of inequitable educational outcomes for marginalized populations. In this paper we address these challenges within the context of mathematics teaching and learning, in the hopes of uncovering how apparent "challenges" can be transformed into assets by creating learning environments in which they are valued and drawn upon. In particular we focus on the relationship between mathematics education, language, and culture through the lens of identity. With our research we seek to provide insight into what a linguistically and culturally inclusive learning environment might look like as well as to describe the impact of embedding mathematics learning within social justice mathematics.

Theoretical Framework

This research takes place in an after-school "math club" for fourth and fifth graders in a predominantly Latino/a (primarily of Mexican origin), border community. Our approach to the activities in the Math Club is grounded in our belief in education as a tool to transform exclusionary situations and to fight for social justice (Freire, 1998). To this end, many of the activities in this mathematics club have a social justice component. Our main goal is to analyze the teaching and learning of mathematics in this after-school setting, in order to identify strategies that provide learning opportunities to all students. In this particular setting, we analyze the relationships that exist between mathematics, language, culture, and social justice.

We focus our analysis on student identity to attempt to understand the impact of an inclusive and transformative learning environment. Several authors emphasize the importance of considering identity in the form of narratives about persons in analyzing sociological and educational processes related to learning and teaching. A student's evolving identity influences how they learn and how they make sense of mathematical ideas. Sfard and Prusak (2005) view "identity-making as a communicational practice" (p. 16), and therefore interaction would be a

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natural place to understand the development of a student's identity in relation to learning. Identity is a concept that allows us to focus on lived realities in context, such as the process of mathematics learning of Latino children in schools, as well as the impact of a unique learning environment such as the Math Club.

Recent research shows that an individual's home, related to history and the social context, is the source of funds of knowledge (Moll & Gonzalez, 2004) that students could potentially bring to learning situations if the learning environment encouraged it. Researchers in critical pedagogy (Gutstein, 2005; Flecha, 2000) claim that these funds of knowledge should be given the same value as traditional "academic" knowledge. Researchers have explored the idea of funds of knowledge specifically in relation to teaching and learning mathematics (Civil & Andrade, 2002), highlighting the fact that individuals have multiple forms of understanding mathematics that are not only in formal ways. There are several experiences around the world that demonstrate a learning environment based on critical pedagogy and the incorporation of students' funds of knowledge, such as Learning Communities (Elboj, Puigdellívol, Soler, & Valls, 2002) and dialogic learning (Flecha, 2000) in Spain, and Accelerated Schools (Levin, 1998) in the United States. In addition, prior research demonstrates the impact of including mathematics funds of knowledge in classroom environments (Civil, 2002; González, Andrade, Civil, & Moll, 2001). These experiences and research demonstrate the need to understand the intersection of mathematics, language, culture, and identity and inform our research.

Methods

Our methodology is based on the communicative paradigm (Flecha & Gómez, 2004; Gómez, 2001) and includes participant observations of students interacting with others as they learn mathematics. According to this methodological paradigm, research is a tool to transform the situations that we are researching. In particular, methodology is seen as a systematic way to understand the inter-subjective relationships that constitute our world in order to find elements with which to transform exclusionary situations. Through our research we seek for ways in which pedagogy can be transformative for students who are often marginalized in our educational system.

Over the course of the past school year, we conducted after-school sessions twice a week during which students engaged in mathematics activities. All sessions were videotaped in order to conduct in-depth reviews of the interactions amongst participants. A graduate student, two post-doctoral students and four undergraduate facilitators were participant researchers who assisted in facilitation and took detailed field notes. Most sessions involved several small groups of students interacting, and so it was imperative that each researcher took field notes to be able to capture all conversations and interactions that might not have been the focus of the videotape.

Evidence

In reviewing our data, we focused on narratives about students in order to understand the multiple elements of language, mathematics learning and culture interacting in the context of social justice mathematics activities. This analysis allowed us to focus on student identity as a way to analyze how these elements played out in interaction in the immediate context while considering social and historical factors that affect student learning. Our examples illustrate the role that funds of knowledge, social justice mathematics, language, culture, and dialogue played in the Math Club learning environment.

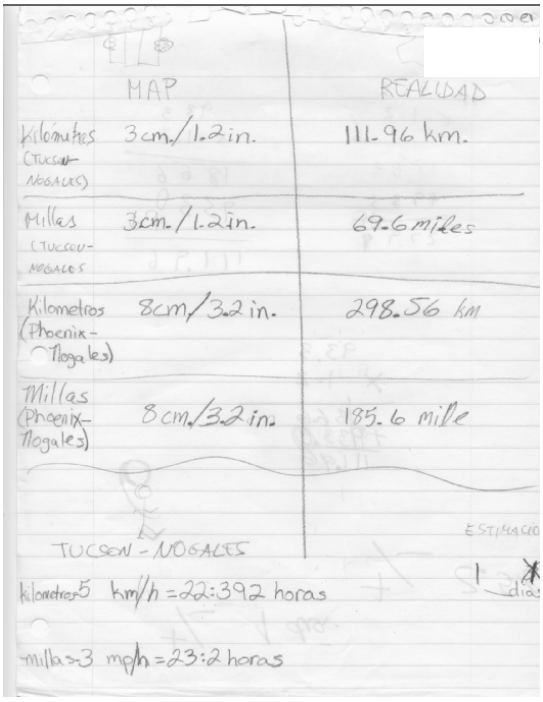
Funds of knowledge

The learning environment of the Math Club was characterized by group work, embedding of activities in real life experiences, as well as facilitators being seen as resources rather than experts. This environment encouraged students to draw on their funds of knowledge easily as they worked to solve mathematics problems related to gardening, such as measuring and evenly dividing up rows, calculating seed depth, and charting plant growth. As students engaged in planning out how to divide up the plots for a garden, they spoke fluidly in Spanish about their prior gardening experiences. One student spoke about how she had learned to add sand to her Nana's garden to save water and ran to the adjacent sandbox to add some to our garden. Another student spoke about knowing how to plant seeds because of work he had done on his uncle's *finca* (farm). Being able to speak in Spanish and positioning all participants as experts enabled these two children who were often distracted in classroom activities or when it comes to mathematics tasks, to engage in the activity and subsequently the mathematics problems.

Identity, language and mathematical understanding in the context of social justice mathematics

During the past school year in which we conducted the Math Club, recent immigration protests began to take place across the United States, in which immigrants voiced their objection to legislation introduced that would criminalize illegal immigrants, among other concerns. During this national mobilization, several participants in the Math Club showed their knowledge of and preoccupation with the issue, prompting us to include an immigration project as a social justice mathematics activity. The direction of the project was open to student input, and we began by questioning the students about the theme of immigration from a mathematics perspective.

The children became very engaged with this project, and because many of them are immigrants or children of immigrants, they drew on resources from their own lived experiences. Two sisters in the program, whose family includes immigrants from Mexico, decided to carry out a survey with family, friends, and Math Club participants to capture their community's opinions about the legislation and protests. They constructed a table with the data they gathered in collaboration with other participants. Several other students decided to calculate the time it takes for a person to travel on foot from the nearest Mexican border city, Nogales, to their own U.S. border city, Tucson. These students used a map, interpreting the scale in order to calculate the distance between cities. They then calculated the total time it would take to walk that distance, using a standard rate for walking in kilometers and miles per hour. The attached picture illustrates one student's calculations and results. In this example we can see how she uses English (and the U.S. system of measurement) as well as Spanish (in terms of vocabulary and in the use of the metric system). Finally, one student sought to represent the distribution of immigrants by gender, in which he discovered that there are more male immigrants than female. In discussing these results with his

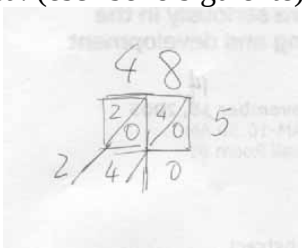
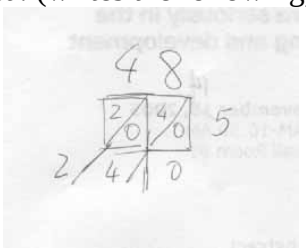


classmates, the students explained that in their experience, seeking jobs is a motive of immigration and that often the male head of household is more likely to be the breadwinner than the female.

Mathematical strategies and dialogue

Dialogue became a natural way to share and learn different strategies to solve mathematics problems, validating students' multiple approaches to formal mathematics. The following dialogue (Table 1), which primarily took place in Spanish, is between a monolingual Spanish-speaking student, a bilingual student, and a bilingual facilitator:

Table 1: Methods of Multiplication

	(Context) Rosa and Jenny are playing with copies of dollar bills. The facilitator has 48 $5 bills. He asks Jenny how much money he has.
Jenny: (va a la pizarra y apunta 48 x 5 –en vertical-) ¡Dos cientos cuarenta! Facilitador: Muy bien. ¿Sabes otra manera más rápida de hacerlo? Jenny: (mira dudando) Facilitador: Imagínate que tienes billetes de 10. Entonces, 48 son 480, ¿no? Pues si tienes billetes de $5, entonces es la mitad... y la mitad de 0 es 0, no? La de 8 es cuatro, y la de 4 es 2, Con lo cual, qué tienes? (escribe 240). ¿Es el mismo resultado, no? Jenny: (va a buscar a Rosa y le hace la misma pregunta) *Do you know another way to do that?* Rosa: (escribe lo siguiente):	Jenny: (goes to board and writes 48 x 5 –vertically-) Two hundred forty! Facilitator: Very good. Do you know faster way to do it? Jenny: (looks doubtful) Facilitator: Imagine that you have $10 bills. So 48 would be 480, right? So if you have $5 bills, then it is half... and half of 0 is 0, right? Half of 8 is 4, and of 4 is 2. And so, what do you have? (writes 240). It is the same answer, right? Jenny: (goes to look for Rosa and asks her the same question) Do you know another way to do that? Rosa: (writes the following):
 	
Jenny: (le explica el método que acaba de aprender). Rosa: (se sorprende con el método "nuevo"). (Researcher fieldnotes, 14/11/2005)	Jenny: (explains the method she has just learned). Rosa: (is amazed by the "new" method). (Researcher fieldnotes, 11/14/2005)

This example shows a dialogue between two children and a facilitator about a multiplication problem. The first student uses a formal method most often used in Mexican schools to solve the problem (presumably because she is a recent immigrant). The second student uses the lattice method (the method that teachers use in her school) to solve the same problem. The facilitator proposes a third way to do the same problem that demands applying logical reasoning based on

knowledge of using ideas such as “double” or “half”. The importance of this dialogue is that the students were able to communicate in the language they are comfortable in, and that dialogue took place in which three different methods of solving the same problem emerged, each with its own cultural origin and seen as equally valid. Deeper understanding and an inclusive learning environment are facilitated as a result of using cultural resources.

Mathematics and language

Over the course of the school year, a shift took place in terms of language use. In the beginning, students often spoke in English, the language of instruction in their school, when communicating about mathematics or as a group. Language use became much more fluid and occurred naturally in context depending on participants, purpose and relationships. On one occasion in the Math Club, a boy who is often distracted and unengaged during his classroom mathematics discussions and activities, tried to explain a concept in English. Another student turned to him and said, “Speak Spanish.” He then started to explain his mathematical thinking clearly and with ease. Also, students were particularly vigilant about translating mathematics books they read at the beginning of the Math Club when Spanish monolingual students were present, a situation that does not happen in their classrooms. Students often grouped together based on language use so that the Spanish monolingual students were able to communicate in Spanish to group members. These situations evolved in the Math Club environment where code switching and language choice happened naturally and fluidly in all aspects of communication, whether it was social or academic discussion.

Results and Conclusions

Our findings demonstrate the importance of language as a cultural mediator in learning (Vygotsky, 1978; Schliemann, 2002) as well as the need to incorporate students’ funds of knowledge in mathematics learning, particularly for students whose language and culture are marginalized in typical classrooms. When the after-school Math Club first started, these primarily bilingual children used only English to participate in the activities. Children asked questions, provided answers and explained their thoughts in English, which is the language used in classrooms for teaching, as dictated by State law. Through observations, we have seen how Latino/a students, many of them recent immigrants and Spanish dominant, began to group with other students who spoke Spanish in order to communicate during mathematics activities. This indicates that language is not only a cultural mediator in terms of an “instrument” that allows us to gain/transmit understanding (in this case in the area of mathematics); language is also a mediator in the range of inter-subjective relationships. Knowledge (or lack of) a language shapes group dynamics in terms of how students interact with each other and in terms of participation and student engagement with activities. During group activities, several Spanish-speaking students who would often appear distracted, quiet or disruptive in their English-dominant classrooms would engage in the activities.

The diverse cultural and linguistic backgrounds of the students also explain the use of different strategies to approach the same operation, as shown in the third example. This demonstrates that prior experience, educational history, and problem-solving methods used by students have a clear impact on the strategies that students use (from the cognitive point of view of mathematical understanding). Here, ideas such as funds of knowledge (Moll & Gonzalez, 2001) or identity development in communication with others (Sfard & Prusak, 2005) play an important role in terms of their contribution in demonstrating and uncovering the social aspect of

learning. We argue that this is essential when planning curriculum and in developing a classroom environment and pedagogical strategies for use in diverse classrooms.

In relation to our second area of interest, the impact of embedding mathematics learning within social justice activities, we have found strong evidence of increased student engagement when using mathematics as a tool to read and write the world (in the Freirean sense) from a critical perspective (Gutstein, 2005; Skovsmose & Valero, 2002; Frankenstein & Powell, 1994). The "immigrant" experience that is a part of the evolving identities of most participants in the Math Club played an important role in involving these students in the activities related to immigration. This kind of activity shows evidence of the importance of embedding mathematics in their lived social context in order to engage students and develop their sense of the importance and power of mathematics. Identity appears as a key element in understanding group dynamics and individuals within a learning environment, and allows us to focus on the development of a learning environment that is inclusive of and empowering to all students.

All of these findings suggest that introducing strategies such as incorporating student culture, language and other funds of knowledge into curriculum and classroom teaching is one way to counter dominant ideologies that create barriers to learning and to overcome inequalities in educational opportunities. Our current research focuses on gathering more evidence to prove (or disprove) these findings and on continuing to uncover methods that will prove useful for teachers in developing their practice in diverse classrooms.

Relationship of Paper to Goals of PME-NA

This research project is the result of the collaboration between a mathematician, mathematics education researcher and educational researcher with a background in educational psychology, all with experience in mathematics teaching. This demonstrates the power of interdisciplinary research in order to understand the complex factors influencing the mathematics educational experiences of diverse students. In order to understand how to reverse the achievement gap for students who are marginalized from the educational system in the United States, we must understand the complex factors that affect and shape student identity, and how this can be affected through culturally and linguistically inclusive mathematics learning environments. Through an examination of the changing identities of students in the context of social justice mathematics learning, we highlight the need to include students' funds of knowledge (including home language and culture) in diverse mathematics learning environments.

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