"Math is Everywhere": Connecting Mathematics to Students' Lives

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Abstract
Este artículo describe una experiencia de enseñanza y aprendizaje de las matemáticas en un programa extraescolar ubicado en una ciudad de suroeste norteamericano, donde los/as estudiantes trabajaron en proyectos mediante los que establecían conexiones entre las matemáticas y sus respectivas vidas. En el proyecto que describimos aquí, los/as estudiantes discuten y resuelven problemas sobre su escuela, su barrio y la inmigración, desde un punto de vista crítico. El enfoque pedagógico de nuestro "Club de Matemáticas" se basa en una perspectiva sociocultural, con una orientación crítica. Esta experiencia destaca las conexiones entre cultura, lenguaje, y diálogo entre los/as estudiantes de matemáticas. Se presentan implicaciones interesantes basadas en el desarrollo de la agencia de los estudiantes a través del aprendizaje de las matemáticas.

This article describes an experience of teaching and learning mathematics in an after-school program based in a southwestern city, in which the students worked on projects that connected mathematics to their lives. In the project that we describe, the students discussed and solved problems about their school, their neighborhood, and immigration from a critical perspective. The pedagogical approach of our "Math Club" is grounded in socio-cultural approaches, from a critical point of view. This experience highlights the connections between mathematics and everyday life that are brought out when emphasizing culture, language, and dialogue among mathematics learners. Implications are made for drawing on student agency through mathematics learning.

Introduction

"Math is everywhere," claimed Dolores, a ten year old Latina and participant in an after-school Math Club. One of the undergraduate facilitators of the Math Club reflected, "I was so proud of her; yes, she understands." What she understands is an explicit intent of our Math Club: to highlight and draw on the connection that mathematics has to the knowledge and life experiences of the participants. This is often not the case for Latino/a students, as their languages, cultures, and experiences are not always represented in traditional classrooms. Dolores's quote demonstrates one result of placing the knowledge and experience of Latino/a students at the center of mathematics learning, where our goal is to transform it from the scary subject many students fear and subsequently remain disconnected from, to one in which they are engaged and empowered mathematics learners. So, what does this look like? We intend to outline a community-based project conducted in this bilingual learning community in order to illustrate how learning mathematics in a learning community inclusive of students' language, culture, and everyday experiences might look.

Over the course of the past year, a team of undergraduate, graduate, and post-doctoral researchers facilitated an after-school mathematics club, in which we attempted to create a transformative, after-school learning space where student experiences and lives outside of school are incorporated into their mathematics learning. Our project is a part of the research of the Center for the Mathematics Education of Latinos/as, which seeks to better understand "the interactions among mathematics learning, language, and culture (especially community knowledge)" (www.math.arizona.edu/~cemela). In this unique learning environment, where we employ strategies of culturally relevant mathematics instruction, we seek to connect mathematics

to students' everyday lives and experiences in order to understand the impact on Latino/a students' mathematics learning.

The Math Club takes place at Agave Elementary, a small (~ 300 students) urban school, located in a predominantly Latino/a neighborhood. At this school, 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 participants in the Math Club reflect the 90% Latino/a student body of the school, all considering themselves Latino/a, and most of them speaking either primarily Spanish, or both Spanish and English. We encourage a bilingual environment with students often switching fluidly from one language to another depending on whom they are speaking to or who is near them. This is particularly salient as the state of Arizona has recently passed legislation to virtually eliminate bilingual education (Proposition 203). The few bilingual education classrooms that are left are severely limited due to increased testing pressures for ELLs. The result of this is that the 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. 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.

Practice Based on Research

Research demonstrates that when teachers incorporate the historically accumulated knowledge and skill bases of their students and the communities from which they come (their "funds of knowledge"), learning is enhanced (González, Moll, Floyd-Tenery, Rivera, Rendon, Gonzaeles, 1995; González, Moll & Amanti, 2005). Civil & Andrade (2002) and Civil (2002) further expand on the theory of funds of knowledge to focus on household *mathematical*

practices while stressing the importance of creating a connection between the academic and the everyday. Because students often feel that mathematics is the subject least relevant to their daily lives, it is an important arena in which teachers can attempt to incorporate students' funds of knowledge in the context of culturally relevant mathematics instruction (Gutstein, Lipman, Hernandez, & de los Reyes, 1997). In this situation, the funds of knowledge of each student would become an integral aspect of the mathematics classroom. Inherent in this approach to pedagogy is the decentering of the source of knowledge from only the teacher or textbook to include student knowledge and skills. The challenge is to then ensure that the mathematics tasks are rich and allow students to wrestle with difficult concepts, while bridging school and out of school mathematics practices (M. Civil, personal communication, June 24, 2006).

Research calling for multicultural learning communities also highlights the importance of creating inclusive, transformative, classrooms in order to engage students in learning (Nieto, 1999; Banks, 2001). Rather than superficially incorporating an activity that serves to represent *the* "Latino/a" culture, which can lead to a misrepresentation of an internally diverse ethnic group such as Latino/as, multicultural education must focus on creating learning environments in which student knowledge is central and equally valued by all participants (Gutiérrez, 2002; Elboj, et.al., 2002). An important aspect of this type of learning community is dialogic learning, based on the notion that students' engaging in dialogue about their thinking and ideas would allow them to include their own knowledge and value that of others (Flecha, 2000). In our Math Club and through the project we describe below, student knowledge is central to the mathematics activities and is brought out in dialogue among all members of the Club.

The Math Club included fourth and fifth grade students who attended two days a week for two after-school hours during the school year. The project we describe below began in

February, and lasted for about three months, until the end of the academic year for the after-school programs at Agave. We attempt to describe how a project based in students' own lives and experiences bridges their life experiences with mathematics, with the potential to develop their conception of mathematics as a tool with which it is possible to transform the world around them.

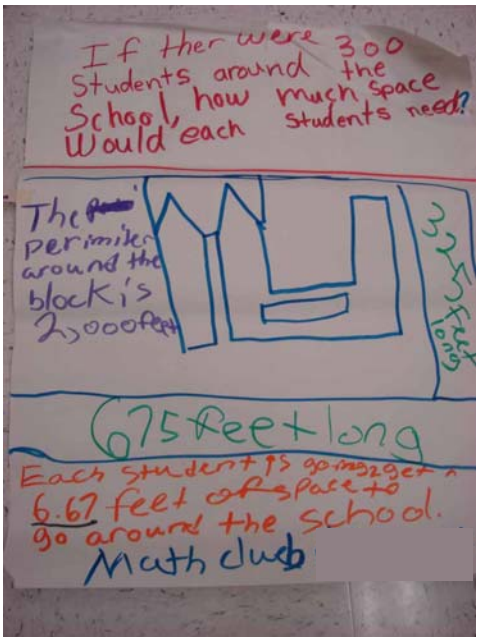
A Community Project

Our project consisted of three parts, set in three different contexts, starting with the one most immediate to students, moving out to those increasingly more global. We began with the students looking at their own classrooms, moved to an exploration of their neighborhood through photographs and discussion, and ended with their creation of mathematical problems that pertain to the entire Latino community in the United States. For the most part, we executed the project as a continuous unit, but with occasional "breaks." These breaks occurred when we were not sure which direction the project should take next, when the students were resistant or uninterested in the activities (as we will explain later), or when other activities or tasks arose based on student interest, holidays, etc... On these occasions, we would engage in other types of activities, such as collective reading of children's mathematics books or problem-solving. This accounts for the three months it took to complete the project.

Measuring the school

The first part of the project lasted three weeks. The students first computed the areas of their respective classrooms in order to determine whose classroom had the greatest amount of space per student. They all concluded that each student had a sufficient amount of space and that

there is no overcrowding at the school. As a part of this activity they also made scale drawings of their classrooms and computed the area and perimeter of the entire school with the use of a satellite picture and scale. The last part of the school measurement activity was more open-ended: each group created a mathematical question about the school, made a poster with the solution and presented it to the other members of the Club. For example, Andres' group explored how many students (holding hands) it would take to (in their words) "go around the school." In other words, their question was how many students it would take to circumscribe the school (see below).



"Go Around the School"

The students probed Andres during his presentation to explain what the group meant by "around the school," how they found the measurements and how they computed the number of students, until they were satisfied with the answer. They even helped him when he got stuck with showing how he calculated the perimeter because he was only adding up two sides. Another group decided to measure the Peace Patio of the school, a favorite location of most students as it

is an inner courtyard decorated with colorful mosaics and murals. This is also the location of school assemblies and so they decided to figure out how much space each student would have if the entire student body was evenly spaced out in the Peace Patio.

The students were able to pose their own problems and worked collaboratively to find a solution that made sense based on the context. Each group worked with an adult facilitator serving as a resource rather than a judge of "correctness" on all parts of the activity. As these were all real-life problems, they did not have "clean" solutions and the students had to grapple with a number of issues in order to solve them. Since none of the classrooms were rectangular in shape, all the groups discussed how to measure irregular shapes and find their areas. They also had to decide how to convert units (among yards, feet and inches or between meters and centimeters, depending on which unit system they chose to work in) and how to choose a reasonable scale for the classroom drawings. They often used original, creative strategies rather than previously memorized formulas. The solutions were the result of mathematical discussions and negotiations of solution methods among the group members, in which every student's voice was heard and valued.

As we share the approach taken in funds of knowledge research, which regards culture as people's daily practices, "what it is that people do, and what they say about what they do" (Gonzalez, Moll & Amanti, 2005, p. 16), we consider the school measurement activity culturally relevant. Students utilized multiple methods and knowledge bases to document space distribution in the classrooms where they spend considerable amounts of time, and engaged in dialogue about the meaning of space per student in this context. Being able to communicate in their home language facilitated their engagement in rich mathematical discussions. Furthermore, as this was the first project in the Math Club that had a considerable social component, it was important for

the students to begin by looking at equity and community issues, even if on a minor scale (classrooms having sufficient space) in a place most familiar to them, the school, before turning their attention to the "outside world."

Community walk

The second part of the project expanded our focus from the school to the community in which our students live. Equipped with digital cameras, on two occasions (on two consecutive weeks) we took walks around the neighborhood in which the school is located. The students were asked to document what they are proud of as well as what they would like to change. Based on student interests, we walked to the library, past numerous murals, to a local church, to the neighborhood convenience store, and paid a visit to the fire station. The students were able to bring in their expertise about the neighborhood to determine the route we would take. Among other things, we took pictures of library books in Spanish, fire trucks, murals, graffiti, trash, and run-down houses. The following photograph was taken by a Math Club student:

Neighborhood Pride

The firefighters gave us a full tour of the station and answered all of the students' questions. While answering these questions, they occasionally used mathematics. For example, one firefighter stated that the fire station gets 1800 calls per year, on average, but that the actual number of calls per day varies greatly, which tied in with the conversations we had been having with the students about the meaning of average. We later made a "thank you" card for the firefighters in which the students calculated how many calls the fire station gets, on average, in one month and in one day.

After each walk we discussed the photos with the students. This gave them the opportunity to talk about their expert cultural and experiential knowledge, which, according to Gutstein, Lipman, Hernandez, and de los Reyes (1997), is a component of a model for culturally relevant mathematics teaching. Among other things, they talked about their families, the stories behind the murals, local businesses, and the history of the neighborhood. They shared considerable information about the life of the community. Patri, who had in the past reprimanded her peers for using Spanish in discussions instead of English, pointed out a mural that portrayed a woman making tortillas and commented that this was how her Nana made tortillas, too. Andres was talking about the significance to him, of the Deer Dancer[1], and most of the students referred to La Virgen[2] as an essential part of their lives. Some were familiar with the location of the WIC (Women, Infants and Children)[3] office and of the local boxing gym. The photographs they had taken also showed their concern with trash and (mostly gang) graffiti that can be found in the neighborhood. When we asked them how all of this was related to mathematics, Marisol responded, "They are not related at all!" But then Briona said that you could organize pictures

[1] A dancer performing the traditional Yaqui deer dance. There is a significant Yaqui population in the area where the school is located.
[2] Virgin of Guadalupe
[3] A Federal mother and child wellness program

by topic, which steered the conversation in the mathematical direction. A lively discussion ensued. The facilitators ensured that the conversation didn't stray from the topic and were constantly probing the students with the question: How could we connect these issues to mathematics? The students responded by generating ideas for possible projects. Due to the content of our two walks, most of the ideas were related to data collection. In particular, the students suggested two such projects: looking at the number of thefts, murders, and drug trade in gangs, and following the daily transactions of the local convenience store. Although the data for the former project would be difficult to obtain, we (the facilitators) suggested we could find information about local crime statistics from the nearby police station and track the convenience store transactions ourselves. The students were also interested in doing a project about the fire station, saying that we could look at the number of received calls, the number of fires put out, or the amount of water used to put out a fire, which is especially relevant during the summer heat and drought in our area.

Although the community walk part of the project was less mathematical than the others, we feel it was equally important. One reason is that the students were encouraged to think about applications of mathematics outside of their classroom. In some previous conversations with students that age, we found that probably due to the nature of their mathematics instruction, students often think of mathematics mostly in terms of numbers or shapes. School mathematics seldom offers connections between mathematics and the students' daily lives, something that we were able to provide in this phase of the project. Another important aspect of the community walk is that we (the facilitators) learned more about the students and their community, which is a critical component of culturally relevant mathematics teaching (Gutstein, et al., 1997). We have found that to establish a mathematics learning community with students, it is equally important

to provide rich mathematical contexts and to constantly make conscious efforts towards community building. Finally, it is an important aspect of incorporating students' funds of knowledge into a culturally relevant mathematics curriculum for teachers to learn more about their students' lives and experiences.

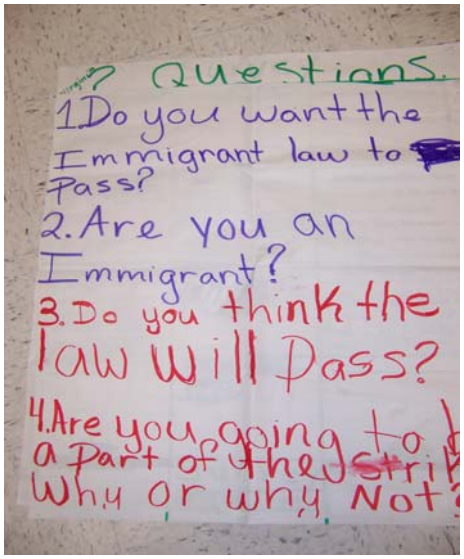
Immigration

Despite the students' active participation in the mathematical discussion following the community walk, they were not convinced there was a good reason for addressing a social issue such as, for example, littering or gang violence with a mathematical project. A belief most of them held was that things are the way they are supposed to be, that they cannot change, and that "nobody would listen to children anyway." Basically, they felt they had no "agency" to change things in the world around them. Gutstein (2006) ascribes this sense of powerlessness that students often have when faced with injustice both to the educational system that discourages children from being critical thinkers and to the paralyzing effect that injustice can have on those experiencing it. To further develop agency in students, he recommends that students learn their own history, that they be presented with examples of positive social change, and that they be given the opportunity to take action.

Following these recommendations, we intended our next step in the project to be picking one or more of the students' ideas from the discussion following the community walk and formulating specific mathematical questions to address. We began to share examples of youth activism enacted by students their age in the hopes of convincing the students that young people like themselves can affect change. However, around this time (April 2006), events happened that especially reinforced the recommendations of Gutstein (2006), changed the course of our project, and affected most of our students. Namely, high school and middle school student walk-outs

were occurring at local schools, based on the community's concern with the national immigration debate. The students began to reveal their own connections to, knowledge of and confusion over this debate. Many felt the need to get involved and were no longer convinced that they were powerless. We decided that the only way to proceed with the project would be to put aside the prior topics and to develop mathematical problems in the context of immigration. Current events provided the students with the opportunity to truly see how mathematics can be used to describe and explore a problem based in their daily lives.

Because this was a sensitive topic, it was especially important for dialogue to take place among all participants. We had a few discussions on the rug (where most of our discussions take place), when the students shared personal or news stories. We encouraged them to think about how they could contribute their stories and information to a mathematics project related to immigration. Veronica, for example, decided to conduct a survey in her neighborhood about the proposed legislation (see figure below).



Veronica's Survey

Although initially one of our quietest students, she had undergone a profound change during the course of the year, and took the initiative to do the survey entirely on her own. The children collaborated to quantify the survey data, creating a table on the whiteboard and calculating fractions and percentages for each response. They also conducted the survey in the Math Club and compared the results, being able to generate data to show the overwhelming community support for the protests, marches and walk-outs. Jacinta found the time it takes a person to walk to the city in which we live from a nearby Mexican border town, while Mónica computed the amount of water and food such a person would need. As Mónica presented the material, she explained: "I figure(d) out how long it takes by walking to [city we live in] by writing one hour and three miles to see how many hours to walk sixty miles[4]. It was twenty hours. How much water would a person need? They would need one hundred and twenty eight ounces and it would be eight pounds. Most people will need eight cups or ten cups. I used eight cups for my chart. How much food would a person need? A medium guy would need two thousand calories with him while walking. Two thousand calories is one pound." When probed by the facilitator to explain what this made her think about, Mónica responded, "Like to see what a person would need while they're walking. If they don't have the same amount they might die." Because it would take 23 hours to cross the border, Jacinta also had to think about the real-life meaning of this number: she had to decide how many hours a day a person could really walk, and how many days the trip would take in order to understand the reality of crossing the border. Dolores and Marisol made a graph of the immigrant population in the United States based on country of origin, in order to understand the complexity of this national issue. In discussing the high percentage of undocumented immigrants who are Mexican, Andres remarked, "They want

[4] By "writing one hour and three miles" she means that she used the information that an average person walked three miles per hour.

to have more money and keep working and have a lot of food for their children." The issue was real and salient to the students as they interpreted the meaning of the statistics presented.

Because of the unforeseen early end of the after-school program in the school the Math Club is based, we had to finish the project earlier than expected. For this reason we were unable to try to present our findings to some of the local officials, our intended audience for the data. We think this is unfortunate, because we feel that it would have had a positive influence on our students' sense of agency in that they could engage in community activism related to the mathematics problems they addressed.

Final Remarks

In this paper we have focused our attention on several examples in which we illustrate how children carried out mathematics in the Math Club environment. The Math Club is a friendly environment, where children are encouraged to make their own decisions and conjectures, and to discover the application of mathematics to real life. This project allowed children to draw on their multiple abilities as well as their prior funds of knowledge in collaboratively exploring a variety of approaches to finding meaningful answers to mathematical problems. These projects were also important opportunities for the children to make meaningful connections between mathematics and their everyday lives, such as through discussions about immigration. This illustrates how the Math Club is not only a place oriented to the study and reflection of mathematics, but also a space where children are free to express and explore their own real life connections to mathematics.

One of the most relevant contributions of the Math Club is that it combines rich mathematics projects and a multicultural learning community that encourages dialogic learning (Flecha, 2000). Through dialogue, children reflected on each other's solutions and connected the

solutions to their real life contexts. Dialogue among children about their peers' answers was a useful way to spark that interest in analyzing a solution's relevancy, as reflected in Jacinta's example in the immigration project. Jacinta found that it would take a person approximately 23 hours to walk from a Mexican border town to the city in which we live. When she presented this answer, someone asked her if it was possible for a person to walk for 23 hours without breaks. She reflected on this, and after a brief discussion with other students and facilitators, Jacinta modified her answer, concluding that, realistically, it would take more than a whole day for a person to cover the distance between the two cities. Jacinta's solution to the problem, presented as simply the number 23, though correct, would not have been an accurate reflection of the real context in which the problem was posed.

An important aspect of multicultural learning communities is that they are not only inclusive of multiple views, but that they are also transformative locations for learning. The project we have described allowed children in the Math Club to find a bridge between their position in their community and mathematics; so mathematics, far from being knowledge separated from the real world, became a tool to understand the role that each person plays in his/her community and the possibilities for making changes in that reality. This project provides a suggestion for a way to think about contextualizing a mathematics curriculum, enabling children to connect their own life experiences with mathematics. Furthermore, we suggest that mathematics can be a powerful way to foster a sense of agency in order to raise critical mathematics thinkers who are prepared to change their world, because "mathematics is everywhere."

Next Steps

As we reflect on the experience of this project, we see areas where we would make changes when done again to enhance the mathematics and draw out the students' sense of agency. During certain parts, we could have made the mathematics content more explicit, such as during the community walk. We could have incorporated more mathematics into learning how to take good pictures, such as with proportion and geometry. In terms of choosing a topic to focus on, we would offer more structure in terms of identifying a problem, working on the mathematics and providing a forum and more meaningful purpose for presenting. With this, students would see the purpose from the beginning and potentially remain more engaged throughout. Also, in the end we were unable to bring the students' findings to a wider audience, which would have further developed the students' sense of mathematical agency. As we enter the new school year, our main challenges are to explore children's thinking in more depth when bridging home and school mathematics in the context of rich mathematical tasks, as well as to then utilize this knowledge in a meaningful forum for expression of student agency.

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