Community Based Mathematics Project: Conceptualizing Access through Locally Relevant Mathematics Curricula

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In this article, we describe a conceptual framework for using locally relevant mathematics curricula to increase access to mathematics for marginalized youth. Drawing on different strands of research on equity in mathematics education, we propose that there are three kinds of access that are afforded by the use of contexts that have local and personal meaning: (1) access to mathematics that matters, (2) access to institutions, and (3) access to critical ways of thinking. This framework was developed in a grounded manner; it evolved through our work with middle school students and their teachers and through our critical analysis of the mid- and macro-level contexts (Irvine, 1990) in which their schooling is situated. In order to illustrate this process, we present this framework as it has emerged. After a brief introduction to the project, we review the research that informs our work and then explicate the three different forms of access that are embedded in our curriculum design.

The Community-Based Mathematics Project of Philadelphia

The Community-Based Mathematics Project of Philadelphia (CBMP)[2] is a group of faculty and students at the University of Pennsylvania along with middle-school teachers in Philadelphia who collaboratively adapt and design context-rich mathematics curriculum to reflect the local community. The project was inspired by our observations of students and teachers using a curriculum called *Mathematics in Context* [*MiC*] (Romberg, 1997-1998) in schools that partner with the university. Although *MiC* uses real-life situations and phenomena to teach mathematical concepts, we found that many of the situations in the curriculum were not connected to the experiences of youth living in urban communities. Some contexts in *MiC*, for example, involve comparing sizes of whales, renting motorbikes during an island vacation, or hiking in the mountains. We initially set out to redesign the math curriculum around contexts more familiar to and meaningful for students in urban Philadelphia. As we introduced our ideas to interested teachers, we realized how important it was to align our work with state standards and assessments and to involve teachers as collaborators rather than simply consumers of our curriculum. The collaborative curriculum design process that emerged served as a valuable form of professional development for teachers as they grappled with the important mathematical ideas in the curriculum. This process also provided the opportunity for our group to better understand the implications of using contexts that were relevant to their students.

Framing Access

In their book *Radical Equations*, Robert Moses and Charles Cobb (2001) stress that access to mathematics learning, and access to algebra in particular, should be viewed as a civil rights issue. Because algebraic knowledge is highly valued by society and often serves as a gatekeeper to educational opportunity, access to this knowledge, they argue, is the first step in gaining access to educational opportunity and subsequent social advancement and success. Through the Algebra Project, Moses developed an instructional approach that builds on youth's real-life experiences (like riding the subway) to develop understanding of more abstract algebraic concepts necessary for success in school mathematics. In their work with Latino families, Marta Civil (2007) and colleagues adopted a similar approach. Drawing on the work of Moll and colleagues (Moll, Amanti, Neff, & Gonzalez, 1992; Moll, 2000), Civil worked with teachers to identify the "funds of knowledge" that are held by the families of their students and build mathematics curriculum around this local knowledge with the goal of connecting mathematics in their everyday experiences with school mathematics.

Although Moses and Civil both take the approach of building on students' life experiences, other efforts to develop mathematics instruction for marginalized populations take an approach that is more explicitly critical and political. Following Freire's call for liberatory pedagogies (1970, 1998), Gutstein (2006) and Frankenstein (1987) have developed pedagogical and curricular methods that not only build on students' experiences, but also support them in developing critical ways of thinking and acting in the world. Often called *critical mathematics* (Frankenstein, 1987) or *mathematics for social justice* (Gutstein, 2006), these approaches aim to develop students' critical consciousness of their realities and facilitate opportunities for students to change those realities. These approaches engage youth in using math to analyze real phenomena in their lives in order to uncover the social injustices. In one example of mathematics for social justice, Gutstein guides his students in examining gentrification in the community, housing prices, and the mathematics behind subprime mortgages. Gutstein argues that social justice pedagogy is aimed at developing in students a sociopolitical consciousness, a sense of agency, and a positive social and cultural identity. This goal is integrally connected to mathematics learning because in order to use their knowledge as an instrument for social critique and change, students must develop deep and flexible understandings of mathematics and positive dispositions toward the subject.

At first glance, these two perspectives appear to oppose one another; Moses and Civil focus on supporting youth to achieve success according to criteria set forth by dominant society and culture, while *critical mathematics* focuses on interrogating and interrupting commonly accepted societal practices. Ladson-Billings (1995a) draws these perspectives together in her conception of *culturally relevant pedagogy*. Based on her research on successful teachers of African American youth, Ladson-Billings argues that true educational opportunity for marginalized students must not only help them experience academic success, but must also support them to develop and/or maintain cultural competence along with a critical consciousness, through which they can challenge the status quo of the current social order. Drawing on the work of Irvine (1990), Ladson-Billings emphasizes the necessity of attending to multiple levels at which marginalized youth are not served well by mainstream education and institutional practices: the "micro-level classroom interactions," the "mid-level institutional context," which include school practices and policies, "and the macro-level," or the societal context (p. 160). In other words, culturally relevant pedagogy, in addition to attending to academic goals, must take seriously the ways marginalized students' experiences are structured by policies, institutions, and societal practices and work with students to confront them.

Ladson-Billings' (1995a) formulation of culturally relevant pedagogy along with Irvine's (1990) levels of social practice underlie our conceptualization of access through locally-relevant contexts. Specifically, locally relevant contexts provide a) access to mathematics that matters in the classroom and schools; b) access to institutions that structure educational and employment opportunities; and c) access to critical ways of thinking about society and social realities. Together, these three kinds of access guide our curriculum development and our work in classrooms. In the following sections, we explore how the use of "locally relevant" contexts—situations and phenomena that have local and personal meaning to the youth for whom the curriculum is designed—provides access to educational and social participation and opportunity at multiple levels of practice.

Access to Mathematics that Matters

A primary goal of CBMP is to provide students with greater access to mathematics understanding and greater success in school mathematics. Locally relevant contexts have helped us address this goal in multiple ways. First, by incorporating locally relevant contexts in the classroom—by translating unfamiliar contexts in the existing curriculum to situations that are more familiar and relevant to students—we help remove confusion surrounding contexts that frequently impeded students' learning of mathematics. Second, by incorporating contexts familiar to students, we leverage their expertise to facilitate learning. Finally, by using context from students' daily lives, we seek to increase their investment in learning and using mathematics outside of school. We hypothesize that this connection increases the likelihood that students will see mathematics as something that pertains to their lives in and out of school. As we describe below, we seek to nurture students' positive mathematics identities by removing barriers that unfamiliar contexts can create and by capitalizing on student's personal, local expertise.

Our initial goal for the project was to address possible impediments to mathematics learning present in the curriculum students encountered in their classrooms. In 2003, the School District of Philadelphia adopted *MiC* as its primary program for middle-school mathematics. *MiC* was developed through collaboration between the Freudenthal Institute and the National Center for Research in Mathematical Sciences Education. The curriculum represents an attempt to translate the Dutch theory of "realistic mathematics education" [RME][3] to a mass-produced, middle-grades mathematics curriculum for use primarily in the United States. The word "realistic" as it is used in RME is translated from the Dutch word "realiseran," which means "to imagine" (van den Heuvel-Panhuizen, 2003). In the first step of RME, students are expected to use their common sense to solve situational problems. For this reason, RME contexts do not need to be authentic or involve situations that students are familiar with; they need only to be imaginable to students.

The teachers we worked with found that many of the contexts in *MiC* did not involve situations their students could imagine. Many of the situations involved activities the students were not familiar with, such as renting motorcycles during an island vacation, hiking in the mountains, or dipping leaves in chocolate. In some cases, teachers found themselves needing to first explain the contexts in the text and then answer questions about *why* people would engage in the particular activity. If the first stage of RME involves using common sense in an imaginable context, the likelihood of early difficulty increases when contexts are completely foreign to students. The context becomes a barrier, rather than a support for further mathematics learning.

From a philosophical standpoint, our group embraced *MiC's* context-rich approach as a strategy for tapping into students' common sense to solve problems. The program embodies the type of pedagogy described in the NCTM Standards (National Council of Teachers of Mathematics [NCTM], 2000) and aligns with our own vision for mathematics instruction. Further, the strategy of beginning with students' common sense solutions promoted by RME resonated with our desire to make math accessible to students. We hypothesized that if the mathematical trajectories in *MiC* could be preserved and familiar contexts were substituted for those less meaningful to students, they would have greater access to the mathematics content. For this reason, we began by translating the mathematical ideas to local contexts in order to remove these obstacles.

An example of this type of translation comes from an 8th grade unit on measuring and representing growth. In *MiC*, a motorcycle-rental scenario required students to compare two companies that offered different daily rates and charges per mile. We translated this context into a situation we suspected students would be more familiar with: comparing cell phone plans.[4] From classroom observations and interviews with students and teachers we gathered that many students had their own phones. At minimum, we hypothesized that they would be familiar with the idea of needing both a phone and some sort of access to a cellular network in order for these phones to work. The imagined scenario we created for the lesson involved purchasing a phone then calculating the total amount spent as monthly payments were made for network access. Students compared pay-as-you-go plans to standard monthly plans offered by the same company, using graphs to find break-even points. They also compared plans across companies. The questions that students were asked to answer were analogues to those in the *MiC* lesson about the motorcycle rentals, maintaining the mathematical trajectory in the original curriculum.

By placing mathematics content within familiar contexts, we also leveraged student expertise and improved student engagement. As Ladson-Billings (1995b) recommends, we sought to use elements of students' cultural lives as "vehicle[s] for learning." Drawing on these local connections aligns with the work of Moll (2000) and others (Civil 2007; Moll et al., 1992; Rosebery, McIntyre & González, 2001) who argue that schooling is more effective if it draws upon knowledge that students come to school with, especially knowledge about the social and economic activities they participate in with their families, friends, and community.

Placing RME into relevant contexts provided the opportunity for students to root their understanding of mathematics in common sense and to connect mathematics to their cultural lives. As we observed teachers implementing the CBMP units, we noticed that students who were experts in the contextual domain tended to become immediately focused and engaged. In another of our 8th grade units, a map of the streets outside the school is used as an example of a transversal intersecting two parallel lines. As the lesson progressed, students identified the equivalent alternate interior, alternate exterior, and corresponding angles. Because the lesson begins with a map of the neighborhood immediately surrounding the school, streets they traveled every day to and from school, every student had a familiar entry point. The teachers needed only to maintain that engagement as the mathematical story was developed, rather than having to build it.

Adapting *MiC* lessons to new contexts also provided the opportunity to address our third goal of helping students to see connections between school mathematics and their lives. Drawing on Martin's (2006) work, we believe that forging positive relationships with mathematics is critical to academic success in mathematics. In order to be successful and persist in school mathematics, youth must see math as something in which they can succeed. Martin defines *mathematical identity* as "the dispositions and deeply held beliefs that individuals develop, within their overall self-concept, about their ability to participate and perform effectively in mathematical contexts and to use mathematics to change the conditions of their lives and also as something that has relevance in their life" (p. 206). By inviting students into mathematics through contexts that are familiar and meaningful to them, we increase the opportunties for success. Further, we emphasize that mathematics does have meaning in their lives.

Access to Institutions

Even when students from marginalized communities have access to mathematics that is valued, they still operate on an unequal playing field when it comes to schooling. Educational opportunities are tied to social institutions (Hallinan, 2000). Thus, a second purpose of our work is to support students in gaining access to social structures and institutions that lead to further opportunities in mainstream society. Our work targets three aspects of the institutional or macro-level context: the institution of formal mathematics as a discipline, the institutionalized mathematics assessed in high stakes tests, and societal institutions that mediate educational and employment opportunities. Using locally relevant contexts in mathematics curriculum creates new opportunities for increasing access in all three of these layers.

Although we take students' cultural experiences as a starting place, we agree with Delpit (1988) and Ladson-Billings (1995a) that it is insufficient to teach students of color to value their own cultural practices. These students also need access to the dominant codes and means of participation in mainstream life. As Delpit argues, "If you are not already a participant in the culture of power, being told explicitly the rules of that culture makes acquiring power easier" (p. 282). Although Delpit's reference is to cultural codes embedded in language, the argument can be extended to the role of formal mathematics as a dominant language in society. Following this argument, it would be insufficient to connect students to the mathematics in their lives; it is necessary to also make an explicit connection to school mathematics in order for students to have access to a dominant form of discourse.

In addition to teaching students the language of formal mathematics, it is also necessary to teach students to wield mathematics as a power in institutions. Mathematics has often been described as a gatekeeper because success in academic mathematics can provide access to opportunities in higher education and employment (Namukasa, 2004; Moses & Cobb, 2001). It is therefore not only important for students who are generally on the margins of society to understand mathematical language but to understand how mathematics leads to success as defined by those institutions. Apple and Beane (2007), though champions of student experiences and creation of knowledge, argue that students still need to be well versed in the "knowledge and skills expected by powerful educational forces," such as test taking skills (p. 19). Teaching students how to achieve in mathematics as defined by societal institutions is a step towards ensuring that students are not denied the educational, occupational, and political opportunities that these institutions provide.

Through our work, we have found that prioritizing access to formal mathematics and achievement is not antithetical to the integration of locally relevant contexts in mathematics curriculum. For example, in a sixth grade geometry unit, we move from identifying parallel and perpendicular lines in local street maps to de-contextualized representations of parallel and perpendicular lines reminiscent of those on standardized tests. In addition, we acknowledge the gatekeeping role of mathematics by paying close attention to what students need to learn to pass those standardized tests. The geometry unit was constructed to specifically address state standards that were not covered by the *MiC* curriculum but were tested on high stakes assessments. Scores on these assessments have significant consequences for students both in terms of where they can attemd high school and in terms of negative sanctions imposed on the school by the district. In designing our curriculum, we identified the topics required by the state and then matched them to contexts that aligned well with these topics and were relevant and engaging to Philadelphia middle school students. Paying careful attention to the topics that were tested also helped us gain buy-in from the teachers and school leaders to implement the curriculum. In this way, locally relevant contexts served as a unique medium through which students were provided access to mathematics and mathematics achievement as established and valued by societal institutions.

We also acknowledge that gaining fluency and proficiency in mathematics is not enough for students to change their social opportunities. The reality is that students often lack access to future opportunities simply because they do not understand the ways in which these institutions operate. One highly consequential institutional structure in the lives of the middle school students in our target population is the high school application process in Philadelphia. Eighth grade students have the option of applying to special admissions and selective high schools or attending their neighborhood high schools. Selective schools have higher graduation and college entrance rates than neighborhood schools and can therefore provide greater opportunities for educational access. Unfortunately, not all school students in Philadelphia have equal access to this process; one recent study found that students living in low-income neighborhoods in Philadelphia are less likely to apply to selective high schools than students from middle-class communities (Gold, Evans, Haxton, Maluk, Mitchell, Simon & Good, 2010). Seeking to increase access to educational opportunities, we have designed the seventh grade units to introduce students to various aspects of the high school application process and support them in navigating this system. Students analyze data about high school and high school admissions through a variety of means, learning about graphic representations, sampling, coordinate planes, plane geometry, and probability. For example, in a unit on data analysis, students create stem-and-leaf plots of the standardized test results of Philadelphia high schools then use scatterplots to investigate the relationship between attendance rates, graduation rates, and college matriculation rates for each of the schools. In this way, students learn the data analysis concepts and procedures they will be tested on while they are simultaneously exposed to information that provides access to the intricacies of the high school application process.

Locally relevant contexts thus play a dual role in granting student access to institutions. First, they facilitate students' acquisition of mathematics knowledge that is valued by society. This knowledge includes both the mathematics that is part of the language and culture of power as well as the knowledge needed to accomplish mathematical achievement as required by society's institutions. Secondly, the locally relevant contexts themselves create an opportunity to teach students about societal institutions and to provide them with tools that they can use to navigate them.

Access to ways of Critical Thinking

In addition to providing access to mathematics and institutions, it is also important to engage students in critically analyzing social conditions that structure their opportunities. Hence, another goal of our curriculum is to inspire students to think in critical ways about their surroundings and situations in their lives that they might typically take for granted. We address this goal by designing lessons that encourage students to analyze forms of injustice in their everyday lives. Our work in this area is informed by the frameworks and analyses of others who have taken up similar goals in education and specifically mathematics (Brantlinger, 2007; Gonzalez, 2009; Gutstein, 2003, 2006; Ladson-Billings, 1995a & b, 1997; Tate, 1995).

Following these scholars, we have made an effort to extend the idea of "locally relevant curricula" beyond contexts that are familiar and interesting. We begin with issues and places that are familiar and pertinent to students' lives, and then provide students with the space and scaffolding to encourage them to critically analyze and question particular aspects of the broader world around them. For example, in a sixth grade data unit, we designed a lesson that utilizes pictographs to represent the sugar content of popular beverages. We additionally provide statistics about the maximum amount of sugar people should consume daily, according to the American Heart Association, and negative implications from overconsumption of sugar. One surprising observation for students is that many beverages that they think of as healthy, like sports and vitamin beverages and fruit juices, actually contain a great deal of sugar. This context simultaneously provokes critical thought about nutrition and lifestyle while engaging students in the mathematics of analyzing pictographs and embedded data. These lessons lead to larger student-driven discussions: what beverages are available in the cafeteria and at local corner stores? How would a tax on sugar (as has been explored in several states) impact the sale and consumption of beverages? Will students change the way they eat and choose beverages in the future? The mathematical content of the unit (graphical representations of data) becomes a tool students can use to analyze and question their world.

In another lesson, students examine bar graphs comparing neighborhood, selective, and special admissions high schools. Students examine graphs that display data about the differences between schools with regard to race, gender, English language learners, students with special needs, students receiving free or reduced lunch, students enrolling late, and percentage of tenured teachers. In addition to learning to read graphs, students are asked to analyze and interpret what they see. They are asked to use the data to argue, based on the differences between the types of schools in Philadelphia, whether or not they believe the admissions process is fair. Although there is not a single correct or ideal answer for this question, students are expected to develop their own arguments, using the data to support their conclusions. The intent is to help students learn to use data to engage in critical analyses of situations in their lives and develop reasoned and sound responses.

Taking on issues of social justice can be complicated, and raising awareness about inequities that immediately affect the students requires consideration of unintended negative consequences. In the lesson involving different types of high schools, for instance, one graph shows that Latinos, Blacks, and males are more likely to attend non-selective neighborhood schools than their White, Asian, and female counterparts. Examining these data could potentially be destructive to students' emotional well-being, especially if they feel powerless to enact change. However, because we designed the unit to expose students to the data along with educating them about the application process while there is still time for them to work to make changes in this area, we hope to mitigate these potential negative effects.

As we highlight situations and institutions in their lives, it is our hope that students will begin to look at these and other instances in their lives in a critical way. We provide students with data and information, and then prompt them to discuss, analyze, and question their world and the choices they make. By bringing to light potentially controversial issues and unfair practices, we create the space for students to use mathematics as a tool to understand and challenge their world.

Conclusions

As we have worked to develop and implement locally relevant curricula, we have arrived at three important perspectives on this work. First, the three forms of access—access to mathematics that matters, access to institutions, and access to critical ways of thinking—are intricately related and mutually transformative. Second, our understanding of what it means to be locally relevant has expanded to include aspects of the math itself, the context used, and the analysis that comes out of the mathematical activity. Third, while the situated nature of this type of curriculum necessarily limits the expansion of this project to a larger scale, we believe that the conceptual framework offers a powerful way to think about the goals of using context in mathematics that can be taken up by others in their local environments.

The relationship between the three forms of access is evident in the lesson in which students analyzed data on the different types of high schools and the high school application process in Philadelphia. Through these activities students are provided access to data that reveals documented inequities in the system; they are also provided access to information that helps them to understand the application process, as well as access to the mathematics knowledge that is valued in the selection process. If students are confronted with the inequities they face in their lives without simultaneously being equipped to successfully engage with these issues, the potential negative consequences may outweigh the benefits. The opposite is also true; students are being underserved if they are given access to rich mathematics understanding, but not simultaneously given access to the full range of high school offerings and the data necessary to make informed decisions. In addition, this context was engaging for the students because it was real data about schools that they were familiar with rather than the kind of fictional or contrived contexts they were used to encountering in math class. When we attend to all three levels of access in curriculum design and implementation, the effect is mutually reinforcing and potentially transformative.

Designing and implementing curriculum around contexts that are engaging and relevant for the students and teachers we work with has also led us to a more nuanced understanding of what it means to be locally relevant. We began with the goal of replacing unfamiliar contexts with more familiar ones, recognizing that what was familiar for many of the young people in West Philadelphia was not reflected in the published curricula being used. Initially we drew from distinctive features of the surrounding community such as public transportation and physical layouts of neighborhoods and streets. Through work with teachers, we came to see that covering the mathematical concepts and skills that were tested on high stakes state exams was also an essential component of local relevance. We learned that relevance is not only a feature of the real-world situations but can also emerge from the mathematical work itself. Through engaging with mathematical concepts inherent in the high school application process and awarding of class grades, students simultaneously learned the mathematics that was assessed on high-stakes tests and the mathematics that acted as a gatekeeper to further educational opportunity. Furthermore, lessons that encourage students to investigate the inequities in these opportunities or the sugar content of snacks sold in the neighborhood corner stores have the potential to change the way local youth interact with their surrounding community in both the short and the long term. Thus local relevance does not only surface from students' familiarity with the context; it can result from the development of mathematical knowledge that matters for school success or the use of mathematics as an analytical tool to better understand and act in the local milieu.

Finally, we believe our conceptual framework can guide others as they approach mathematics instruction in their own local contexts. We acknowledge that developing mathematics curricula that is locally situated necessarily limits the scalability. It cannot be predetermined and prepackaged for wide scale use; instead it must be developed collaboratively with teachers and students, and may need to be continually adapted to fit the dynamics of the local context. However, it is by working within the local and particular context, and in collaboration with teachers and students, that we have been able to understand how to simultaneously increase access to the mathematics, institutions and critical ways of thinking. When designing curriculum activities, we should see context as a tool to remove potential barriers and increase student engagement, while also preparing students for external high stakes tests, increasing their knowledge of institutional structure of schooling, and helping them take a critical stance towards social conditions in their own community. This framework, which we hope will be taken up and expanded on by others, offers great potential for transforming the educational opportunities for urban youth.

ENDNOTES

1. All authors contributed fully to our work and the development of the ideas presented in this paper. The order of our names was determined randomly.

2. The project is funded with generous support from Ruth Moorman and Sheldon Simon and the Netter Center at the University of Pennsylvania.

3. RME was developed at the Dutch IOWO, which is translated as the Institute for the Development of Mathematics Education.

4. We recognize that students ultimately should be able to make sense of new situations like these and see the mathematical structure in all of them. We posit, however, that when students are learning a concept for the first time, the context should provide an accessible support, rather than an additional sense-making demand. Further, in future lessons students had ample opportunities to apply this understanding to more unfamiliar contexts since our adaptations only represented a portion of the existing curriculum.

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