Increasing Access to Mathematics through Locally Relevant Curriculum

Janine T. Remillard, Caroline B. Ebby, Vivian Lim, Luke T. Reinke, Nina Hoe and Emily Magee
Graduate School of Education, University of Pennsylvania
Philadelphia, PA

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A 7^{th} grade class was in the middle of a unit on data analysis. Instead of using the regular textbook that day, the teacher distributed a table of data reporting attendance and graduation rates of local high schools. Students looked down the list of schools and immediately began talking excitedly: "Look, there's Kennedy!" "Can you find Truman?" "I see Performing Arts Academy." Gradually the volume began to rise: "Check this out, there's Culinary Arts – that's where Jose goes!" "My cousin goes to West!" The teacher used all her standard attention-getting signals, but was not able to draw their attention away from the list of high schools in their district. "Whoa, they have a school for just girls?" "There's a school for music? I wanna go there!"

Captivated by their engagement, the teacher allowed the students several more minutes to explore the data before beginning the planned lesson activities. She encouraged them to pose questions and look for patterns. Eventually, they plotted the attendance and graduation rates on a scatterplot. When they saw the completed graph projected on the screen at the front of the room (see figure 1), students immediately noted that schools with higher attendance rates had higher graduation rates. What's more, those schools with more than 90% in attendance and graduation rates were almost all "special admission" schools, or selective schools that students must apply to in order to gain entrance. The neighborhood high schools, the default choice for most of the students, were all in the bottom cluster. Over the next few days, the students used related high school data to learn how to plot points, create and interpret scatterplots, and make sense of concepts like correlation and sample size. They began to question how data are collected and reported—what does it mean if a school has an average attendance rate of 75%? How is that figure computed? What counts as an excused absence?

A few weeks later, the same 7th grade students attended a high school information fair. The counselor reported these students were unusually motivated as they visited each table, asking questions about graduation rates, attendance rates, and other data they had learned about.

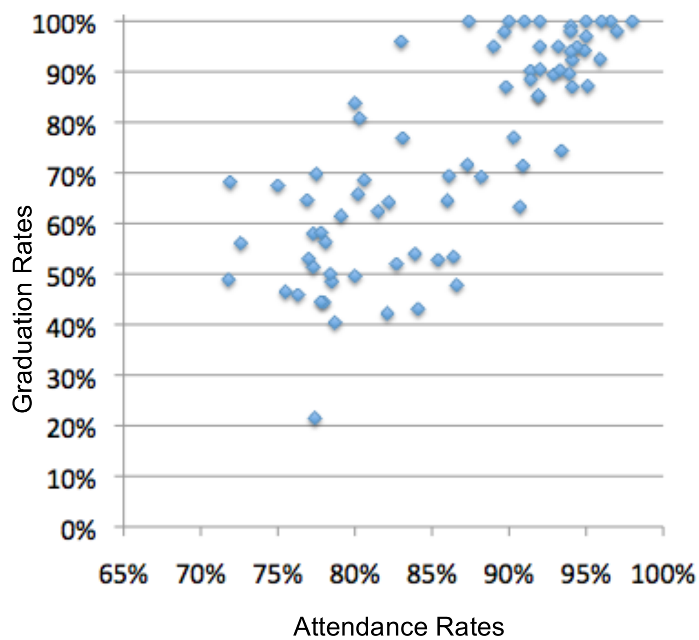

Figure 1: City High School Attendance and Graduation Rates

The opening vignette describes the experiences of a teacher who participates in the Community Based Mathematics Project of Philadelphia (CBMP), a group of university faculty and graduate students along with middle-school teachers in Philadelphia who have been working together to adapt and design context-rich mathematics curriculum to reflect and leverage resources in the local community. By context-rich curriculum, we mean curricular resources, including instructional plans, lesson guides, and student tasks, that use real-life situations and phenomena to generate and build mathematics concepts. The curriculum development and research project grew out of our work in two middle schools that were using a published curriculum program called *Mathematics in Context* (MiC) (Romberg 1997-8). As the title suggests, MiC was also context-rich; the program used realistic situations, such as comparing sizes of whales, renting motorbikes during an island vacation, or hiking in the mountains, to generate and model mathematics problems. Because many of the situations in the program were not familiar to the youth living in this urban community, we worked with teachers to redesign the materials to include contexts and situations that were more relevant to the middle school students served by these schools. Our initial goals were to use local contexts to help youth gain access to mathematics that matters in their lives and to support them to develop mathematical tools for critical thinking and action in their lives (Freire 1994; Gutstein 2006). Through a cyclical process of design, implementation, and revision, we developed a conceptual framework to guide our ongoing work. As we describe in this chapter, the framework, comprised of three critical points of access, provided us and the teachers with whom we work ways to make theoretical concepts more concrete and applicable to urban classrooms. (For more detail, see Ebby et al. 2011.)

In the pages that follow, we define *locally relevant curriculum* and introduce the framework that has come to guide us. We also illustrate the framework through description and analysis of several lessons that were collaboratively developed and implemented in middle school classrooms. We hope that educators interested in making mathematics relevant for their own students can not only use and adapt these examples for their own classrooms, but also draw on our framework to develop new lessons and activities that are unique to their own local community.

Locally Relevant Contexts and Points of Access

We use the term "locally relevant" to refer to curriculum and pedagogy that take into account the contexts of students' lives, what they know and are interested in, and the social realities and issues that matter to and for them. Informed by Ladson-Billing's (1995) concept of culturally relevant pedagogy, and critical pedagogies inspired by Freire (1994), our goal is to simultaneously attend to three interrelated points of access for students: a) access to mathematics that matters for their lives, in the classroom and schools; b) access to institutions that structure educational and employment opportunities; and c) access to critical ways of understanding and analyzing social institutions, structures, and practices. As we illustrate in the description of the framework, attending to each of these points of access is critical to designing curriculum that fully accounts for the realities of students' lives.

Access to Mathematics that Matters

The first point of access is to mathematics that matters. What kind of mathematics matters for middle school youth? First it must be mathematics that they can use to understand and apply to situations in their lives, or as Freire (1994) says, to "read the world." Yet we believe it is equally important for students to gain access to the ways of representing mathematics that are valued and assessed in school and to knowledge that lays the groundwork for further study of mathematics. A primary goal of our work is to provide students with both greater understanding of mathematics and an increased level of success in school. Locally relevant contexts help us achieve this goal by building on the knowledge students already have and increasing their engagement in learning new concepts.

In the opening vignette the teacher was piloting a lesson that replaced the context in the MiC curriculum, data on the relationship between the heights of fathers and sons in the early

1900s, with one that was more familiar and relevant to her students, data on local high schools. She did not need to spend time explaining the context to her students, as she found herself doing with other lessons in the textbook. This context was quite familiar, and, even more than she anticipated, it leveraged the students' interest and expertise. Because students were approaching the high-school application process, the revised context heightened their engagement and suggested that mathematics was something that pertained to their lives in and out of school.

In fact, the idea to use high-school data as a context, like many of the contexts we used, emerged from the initial step in our inquiry process, asking youth about their lives, interests and concerns. Many teachers in urban classroom live outside of the communities where they teach and may hold general or stereotypical knowledge of their students' cultural or community experiences (Tate, 1994). Our informal conversations with students led to a number of anticipated contexts as well as some that surprised us. Students near the end of 7th grade, for instance revealed both eagerness and unease about the forthcoming high school application process.

The goal of increasing access to mathematics can often be accomplished by replacing the contexts used in the textbook with familiar and high-interest situations, while maintaining the same mathematical focus and trajectory. For example, in an 8th grade unit on measurement and growth, we replaced the context of a motorcycle-rental scenario that required students to compare companies that offered different daily rates and per mile costs with one that involved cell phone plans, a more familiar situation for our students. Students compared pay-as-you-go plans to standard monthly plans, using graphs to find break-even points. Similarly, in a 6th grade unit, instead of having students compare the lengths of different types of whales to teach multiplicative comparisons and graphing, we had them compare the lengths of local buses, trolleys and trains. We used a map of the streets around the school to illustrate a transversal intersecting two parallel lines, and we had students identify the equivalent alternate interior, alternate exterior, and corresponding angles.

These examples were adapted from the existing program lessons. We also worked collaboratively with teachers to develop new lessons grounded in students' everyday experiences. One teacher in our group decided to use her students' interest in popular music to teach concepts of ratio. She created a lesson where she had her students listen to popular music, use ratios to describe the structure of the songs, and then investigate, questions such as what proportion of the entire song consisted of the refrain? When she presented the lesson to other teachers in our group, we explored the mathematics further by using the bar model to represent these ratios. Another teacher decided to adapt the lesson and had students use the bar model to map out the parts of a song together (see figure 2). In a subsequent session, the group further refined the activity, adding in the use of percents to make comparisons and identify similarities and differences between song structures.

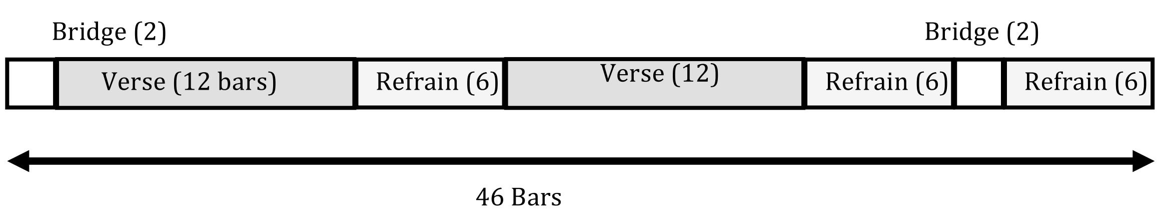

Figure 2: Example bar model for parts of a song.

Through classroom observations and interviews, as well as teachers' reports, we noted that, when familiar contexts were introduced, students became immediately focused and engaged. As illustrated in the opening vignette, the expertise students had about the local high schools–their knowledge of their own school data and their familiarity with the stories of classmates and friends–gave the data real significance. The fact that they would soon apply to high schools piqued their interest in the data and the story it had to tell. Having expertise in the problem contexts also seemed to increase students' confidence in working with the content. During a focus-group interview, we asked students about the value they saw in using local contexts. One student remarked, "It was like we had a home-field advantage." Martin (2006) asserts that in order to gain access to mathematics, youth need to see mathematics as a subject matter in which they can succeed. We found that using relevant contexts to teach mathematics leveraged their local knowledge and helped them see it as relevant and accessible. They learned to see mathematics as "sensible, useful, and worthwhile," an integral part of mathematical proficiency as defined by the National Research Council (NRC 2001, p. 116).

Access to Institutions

When students from marginalized communities have access to mathematics that is valued, they still may operate on an unequal playing field when it comes to schooling. Gaining fluency and proficiency in mathematics is often not enough for students to gain access to new opportunities; many lack access to opportunities simply because they do not understand the ways in which social structures and institutions in mainstream society operate. We learned from our work that strategically selecting relevant contexts was not only a way to help youth gain access to mathematics that mattered, but could also help them gain critical knowledge of systems and how to navigate them. For this reason, we argue that curricula and pedagogies that take into account the real contexts of students' lives and the social realities that matter for them must include access to institutions.

The high school application process is an example of a highly consequential institutional structure in the lives of the middle school students in our target population. Eighth grade students have the option to apply to special admissions high schools or attend their neighborhood high schools. As the 7th grade students in the vignette discovered, selective schools have higher graduation and college entrance rates than neighborhood schools and can therefore provide greater opportunities for educational access. Unfortunately, not all students have access to information and resources needed to participate in the high school application process; one study found that students living in low-income neighborhoods in Philadelphia were less likely to apply to selective high schools than students from middle-class communities (Gold et al. 2010). Creating a scatterplot of the attendance and graduation rates of the city high schools comprised the first of several lessons designed to introduce students to data analysis techniques and information about high schools in their city and arm them with knowledge and confidence that might bolster their participation in the application process. We also developed a set of lessons that used geometric principles to explore locations of and distances to various schools and others that explore simple and complex probability through calculating the chances of admission to multiple schools.

Although we use students' social and cultural experiences as a starting place, we are intentional about making explicit connections to mathematics as defined in school. Mathematics has often been described as a gatekeeper because it is the subject that most often keeps students from progressing in higher education (Moses and Cobb 2001). It is therefore critical for youth to understand how success in mathematics can open institutional doors. One way that we acknowledge the gatekeeping role of mathematics is by paying close attention to what students need to learn in order to pass tests that have consequences for them—both in terms of where they can attend high school and in terms of negative sanctions imposed on schools. After identifying the state standards that would be tested at each grade, we matched them to relevant contexts that aligned with these topics and were meaningful and engaging to middle school students in our local community. We then built a bridge between their situated understanding and the types of questions they were likely to see on standardized tests. For example, in a 6th grade geometry unit, we move from identifying parallel and perpendicular lines in local street maps to de-contextualized geometric figures.

Locally relevant contexts play a dual role in granting student access to institutions; they facilitate students' acquisition of mathematics knowledge that is valued by society, but also create an opportunity to both teach students about societal institutions and provide them with the tools that they need to navigate them successfully.

Access to Critical Ways of Thinking

In addition to increasing access to mathematics and institutions, using contexts from students' lives can also help them learn to use mathematics as a tool for creating change. We have found that locally relevant contexts can be used to encourage students to analyze forms of injustice in their everyday lives and think critically about situations they might typically take for granted. Following others who have championed the notion of culturally relevant mathematics (Gutstein 2006; Ladson-Billings 1995; Tate 1995), we extend the idea of "locally relevant curricula" beyond contexts that are merely familiar and interesting. We begin with issues that are meaningful to students' lives, but provide opportunities and scaffolding to encourage them to critically analyze and question aspects of the broader world around them, the third point of access in our framework.

After examining rates of attendance and graduation in local city high schools, 7th grade students began to explore the inequities in the high school admission process in their city. Because one of the contributing factors of these inequities was lack of adequate information about high schools, students gathered and compiled data on enrollment, diversity, attendance, school violence, state assessment scores, and higher education rates of local high schools. They also analyzed data on enrollment in different types of schools by race and gender. In addition to learning to construct and interpret graphical displays, students were expected to use these data to make an argument about whether they believed the admissions process was fair. Through this type of task, students learn to use data to engage in critical analyses of situations in their lives and develop reasoned and sound responses.

For a 6th grade data unit, we designed a set of lessons in which students analyze the sugar content of popular beverages using proportional reasoning and unit rate. (See Ebby 2013 for detailed lesson plan.) We also provided statistics on the recommended amount of sugar people should consume daily and negative implications from overconsumption of sugar. A surprising observation made by students was that many beverages they considered healthy, like sports 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 creating and analyzing graphs. These lessons can often lead to additional questions to pursue: What beverages are available in the cafeteria and at local corner stores? How would a tax on sugar (as has been explored in several cities) impact the sale and consumption of beverages? Will students change the way they choose beverages in the future? The mathematical content of the unit becomes a tool they can use to analyze and question their world.

As we highlight situations and institutions in their lives, our goal is for students to begin to look at their experiences through a critical lens. 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, engaging them in important mathematical practices, such as using mathematics to "construct viable arguments and critique the reasoning of others" (CCSSI 2010, p. 6).

Implementing the Framework

Developing and implementing locally relevant curricula in our own community has led us to perspectives that are likely to have relevance for multiple local environments. First, the three points of access—to mathematics that matters, to institutions, and to critical ways of thinking—are intricately related and mutually transformative. Their interdependence is explicitly illustrated by the lessons that revolve around the high school application process. Students learn the mathematics and engage in mathematical practices that they need in order to be successful in school and beyond through a context that is familiar and engaging. At the same time, they learn about the high-school admission process, including inherent inequities, lack of transparency, and other barriers they might face. The mathematics they learn empowers them to gather information and use mathematics as a tool to understand, participate in, and critique institutional structures in their lives. If students are confronted with inequities they face in their lives without simultaneously being equipped to successfully engage with them, the potential negative consequences may outweigh the benefits. The opposite is also true; students are underserved when they are given access to rich mathematics understanding, but not simultaneously given access to data and ways of making sense of those data in order to make informed decisions.

Second, the conceptual framework offers a strategic approach to using contexts in mathematics that can be taken up in other locations. We have learned that developing locally situated mathematics curricula necessarily limits its scalability; it cannot be prepackaged for wide-scale use. Instead it must be developed through local knowledge and may need to be continually adapted to fit the dynamics of the context. Even though this may seem to be a limitation, our interviews and conversations with participating teachers revealed that engaging in this ongoing work led to significant outcomes for their own professional growth.

Teachers reported that participating in the cycles of curriculum design and piloting served as a powerful form of professional development and affirmation; it deepened their understanding of both the mathematics and the curriculum, and it led to stronger connections with their students. Over time our project has shifted into a professional community of university researchers and school-based practitioners. We meet regularly to explore the mathematics in locally relevant contexts and then collaboratively design, reflect on, and redesign lessons. Teachers try out the activities with their students and then share their experiences with others in the group, raising questions and additional ideas for extension and improvement. The lessons we have described in this chapter have gone through further cycles of implementation and redesign as they are implemented with particular groups of students in different school contexts. Through this process, curriculum has become a living, growing entity, rather than a static set of activities to be implemented, and as a result teachers have gained both a sense of investment and professionalism. Thus, the process is generative in multiple ways.

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