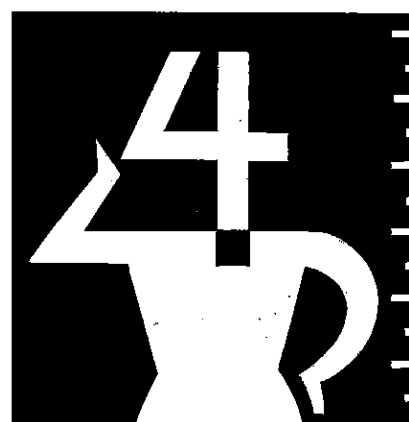
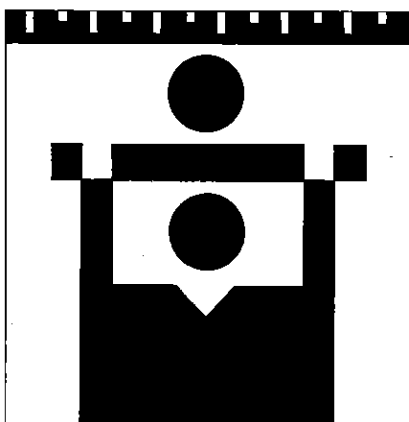
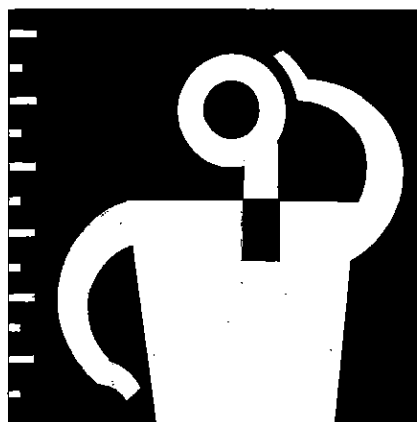


Students Use Math to Confront Overcrowding

By Erin E. Turner and Beatriz T. Font Strawhun



DAVID MOLIMANS

In an overcrowded New York middle school, students discovered that math was a path to investigating and working to change conditions at their school.

After planning a unit with Erin, a university professor, Beatriz taught a six-week unit where students used mathematics to investigate issues of overcrowding at Francis Middle School, which is located in a predominantly working class African-American, Dominican, and Puerto Rican community in New York City. Erin was present in the classroom for all of the class discussions.

When the school opened in 1990, following a district call for the creation of more "small schools" for middle-grade students, the founding (and current) principal faced the near impossible task of finding available space for the school within the district. At that time, the elementary school that currently shares a building with Francis had vacated the top floor because of

continual problems with a leaking roof. Francis's principal claimed the space for the new school, repairs began, and the school opened shortly thereafter.

Although Francis began as a small school, districtwide changes in student enrollment caused the school's student population to grow dramatically, from approximately 145 students to 213 students, and it was projected to grow another 15 to 20 percent (an additional 30 to 40 students) the following year. So as students climbed the five flights of stairs to reach the once pigeon-infested fifth floor that now housed their school, they worried about how the narrow halls and lack of classroom space might accommodate their already cramped school community. Some students were concerned about the potential fire hazards created by the school's long, narrow hallways. A building across the street had recently been damaged in a fire, and in the aftermath of 9/11, students were all too aware of the dangers of being

trapped in a burning building. Others felt their classrooms, several of which had recently been subdivided to create multiple rooms, were too small and overcrowded. Floor-to-ceiling columns and smaller poles scattered throughout classrooms made simple tasks like seeing the chalkboard difficult.

It was students' concern about the lack of space at their school that guided the initial development of this project. One of our primary goals was to design a unit of study that drew upon students' interests and experiences, and provided students opportunities to learn and use mathematics in personally and socially meaningful ways. With this in mind, Beatriz asked students to make lists of issues about the school and local community that concerned them.

Several topics appeared repeatedly in students' lists, including violence in the neighborhood, health issues such as AIDS, racism and sexism in the media, and the "space crisis" at the school. While any one of these topics might

have sparked a rich mathematical unit, we selected the issue of "Overcrowding at Our School" for several reasons, including (a) the rich mathematical content the unit would draw upon, (b) the opportunities it would provide for students to generate their own data, versus analyzing data from an external source, (c) the salience this issue had for students, and (d) the potential links to issues of equity and fairness.

Initially, students claimed they were more crowded than other schools and were eager to speak out in hopes of increasing their school space. Students were particularly bothered by the disparity they observed between their own school space and that of Longmore, another small middle school that had recently moved into the fourth floor of the same school building. (Note: When the fourth floor initially became available, Francis lobbied to move into it, but the request was not granted; the space was instead awarded to Longmore, a technology magnet school that attracted affluent, predominantly white families from across the district.)

Yet students were not sure how to talk about the crowding in terms that might convince others, and it was unclear to them how mathematics could support their argument. To help students connect their concerns about overcrowding with mathematical tools that would support their investigation, Beatriz posed questions such as, "How can we show them how much space we have? What kind of information would we need to collect? What kinds of measurements? How can we prove that we are more crowded than Longmore?" Students quickly realized that quantifying the school's space would be helpful.

One student, Jhana, raised a concern about the tight space in the hallways after second period, a time when all 213 students in the school were simultaneously released from their

classrooms. In class, she repeatedly lobbied to investigate this. "What we need to know," she argued during a discussion, "is after second period, because that's when the most kids come out. How many kids get dismissed? . . . And

*"With math it's
like you have
more defense."*

[we need] the area of all the hallways." Other students agreed that finding the area of classroom and hallway spaces would "give proof" to their claims of overcrowding, and so Beatriz prepared a series of mini-lessons that addressed concepts such as linear measurement, and how to find the area of spaces with mixed number dimensions, such as a hallway that measured 10 $\frac{1}{2}$ meters by 1 $\frac{1}{4}$ meters.

Jhana worked with several classmates to measure and calculate the area of the school's hallways, and used ratios to compare the hallway space per student at Francis to the hallway space per student at Longmore. She argued that ratios "make it easier to see the big difference," and noted:

[Before] I wouldn't really use math. I would just say, LOOK how much space they have [in their school] instead of what we have [in our school]. . . . But I would really use math now. . . . Math made my argument make more sense, and have more of an idea, and actually tell what is happening, because it gave more detail to it.

As the class continued to analyze overcrowding at their school, they discovered disparities between their own space and that of other schools, and numerous instances where their school violated district building codes.

For example, during one lesson after students had worked in teams to measure and calculate the area of different classrooms and hallways, Beatriz asked each group to share their measurements. Students were shocked as they viewed the size of their own classrooms (e.g., 474, 497, and 567 square feet) compared to the classrooms at Longmore (e.g., 772, 864, and 918 square feet). One student commented, "It's not fair! They have a smaller amount of students and bigger classrooms. They have to keep cutting our classrooms in half because we have so many kids."

Ultimately, students decided to share this information with the district. They wrote letters to the superintendent, prepared fact sheets with the results of their analysis for administrators, and spoke at a school governing board meeting. As Jhana considered whether the students' analysis of the space crisis at their school made a difference, she commented: "Yes [we made a difference], because first of all, we found out something for ourselves, and we actually proved a point. Math made our argument make more sense. . . . You couldn't do it without the math."

As mathematics educators, we would like all of our students to exhibit such passion about the power of mathematics. Jhana and her classmates invented novel problem-solving strategies, and used mathematics to analyze and act upon situations at their school. We believe that students' participation in this unit helped them develop a sense of themselves as people who make a difference.

Students Negotiate Curriculum

Throughout the "Overcrowding at Our School" project, the students had opportunities to insert their interests, goals, and purposes into the curriculum. For example, after several days of measuring classrooms and calculating

areas, students formed small groups to pose their own problem about a particular aspect of the school space. Beatriz asked students to identify one issue dealing with overcrowding at the school and to discuss how they might use mathematics to find out more about the situation. As students posed problems that mattered to them, their desire to understand and affect the overcrowding increased their engagement in mathematics and enhanced the learning that occurred.

Angel, a tall and rather quiet African-American student, was not a frequent participant in problem-solving discussions before this unit. But when the class began to investigate overcrowding at their school, there was a notable shift in Angel's level of engagement. Angel was extremely concerned about the school's bathrooms.

She found it difficult to navigate among the other 10 or 12 people in the tight space. She noted that all females in the school, including 103 students and 15 teachers, had to share one rather small facility with only three working stalls, and a very small sink station. So when Beatriz asked Angel's group what aspect of the school space they wanted to investigate, the choice for Angel was obvious: "We want to know, why are the girls' bathrooms so small?"

Angel's group constructed a floor plan of the restroom, measured its dimensions, calculated the area, and then analyzed the bathroom space based on the number of stalls, the estimated wait time during peak use periods, and the space available for waiting. Angel spoke about how the opportunity to investigate an issue she cared about made her feel "mad curious" and drew her into the mathematics. She commented, "It was easier to do the math this way, instead of just learning it straight, like solving a problem, because we would actually really get into it, and that made it easier."

For other students, the opportunity to investigate real issues not only increased their engagement, but also pushed them to construct and apply important mathematical concepts.

Lianna, like Jhana, was concerned

area of Longmore, and I want to see how much [space] they will each get. You found out how much each person will get in Francis, and I want to do the same thing in Longmore. But I don't know how to do it."

Discussions began with matter-of-fact statements about the data, but shifted to an exploration of why particular discrepancies existed.

about the school's narrow and densely populated hallways. As she left Beatriz's classroom each day, she faced the challenge of navigating through one of the school's narrowest and most densely populated hallways. Not a student who was comfortable pushing her way through oncoming crowds of up to 80 children at a time, Lianna was often left standing just outside the door for four or five minutes while other students passed in and out of adjacent classrooms. Her group decided to compare the total hallway area at Francis with the area of the hallways of Longmore.

The mathematics that Lianna's group engaged in would qualify as rigorous in any sixth-grade classroom. They developed their own strategies for multiplying mixed numbers to find the area of hallways with dimensions like $18 \frac{3}{4}$ by $1 \frac{1}{4}$ meters, and subdivided irregular spaces into rectangular and triangular areas.

But Lianna was not content with simply stating the total hallway area of each school; she wanted to make her argument stronger, or to use her words, to "use more specifics so people will listen." When she overheard that a classmate, Thomas, had calculated hallway space per student, she was intrigued.

"How did you do that?" she asked. "We already found out the [hallway]

"You've got to know how many students there are," said Thomas.

"Sixty," said Lianna.

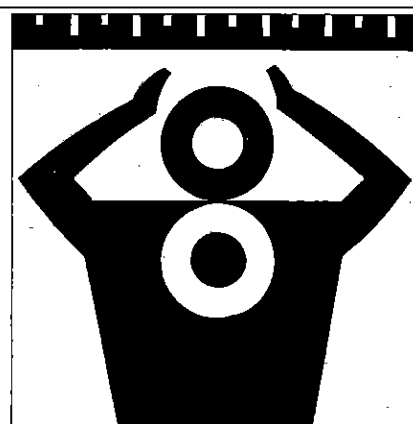
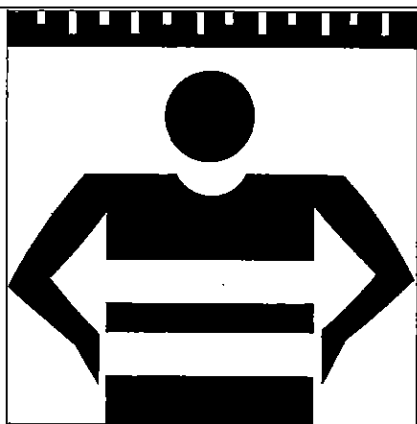
"Sixty students. And how much is the area?" asked Thomas.

"246 and $\frac{3}{4}$ meters squared," she answered.

"So I am going to divide 60 into 246," said Thomas. "Because that way I can find out how much each person gets, cause it kind of divides it [the space] up."

Several days before this conversation, Beatriz had presented a mini-lesson designed to help students think about overcrowding in terms of "space to people" ratios. Many students found that comparing ratios helped support their claims about overcrowding, and some, like Thomas, had become adept at using this mathematical tool. It was not uncommon for students in the classroom to ask each other for help, or to question one another's strategies in order to understand them better, as Lianna did.

With Thomas's help, she figured out that if all students at Longmore entered the hallways at the same time, each student would have 4.1 square meters to herself or himself. She was shocked when she compared that figure to the less than 1 square meter of hallway space allotted to each student at her school.



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Taking Action

We wanted to support students in sharing what they learned through their investigations with the school and neighborhood community. Beatriz helped students brainstorm ways to educate others about overcrowding at the school. Students generated lots of ideas, including distributing fliers, visiting the school board, going “on strike,” making a large floor plan of the school to display, and compiling all their data to share with the district. Except for going on strike, the students implemented all of these ideas.

At the end of the unit, Naisha, a spirited and opinionated African-American student, spoke at a school advisory council meeting. This council represented the school at the district level, and helped make decisions on matters of spending, curriculum and assessment, staffing, and enrollment. Naisha embraced the opportunity and volunteered to prepare a speech. What follows is the text of the speech she presented to the board:

Good evening, my name is Naisha Watson. I am a 6th grader at Francis Middle School, and I am going to talk about overcrowding at our school. Our math class has been comparing our school to Longmore. We have noticed, as a class, that we have no space for kids to sit. ... The board of education has a build-

ing code that the classrooms have to be at least 750 square feet for 30 children. As you can see on the graph, only three classrooms are big enough, the rest of the classrooms that are orange on the graph are smaller than 750 square feet. [Refers to a large diagram of the school created by several students.] ... The board of education has another building code that says the hallways must be 5 feet and 8 inches wide. ... There is only one hallway that is 5 feet and 8 inches. All the other hallways that are red on the graph do not meet the board of education building code. ... In our school we have 213 kids. If there was a fire in our school, it would be a hazard to get through our narrow halls. So, as a school, we think we should have less students or more space.

Naisha felt that speaking out as a way of resisting the inequities her class discovered was not only necessary, but also potentially effective. “I think it’s good [that we talked to the district], because if you keep talking to them then they will probably listen,” she explained. “And you will get on their nerves and maybe then they will want to give us more space, or let us be in a different building with more space, [space] that is lawful.”

Even though the students knew that the district lacked funds to build a new

school or add a floor to the building, they felt good about contributing to the public discussion of overcrowding at the school. As Lianna argued, “We have to say something because we are the students and we are the ones that have to live in the school everyday.”

Not only did opportunities to engage in responsive action support students’ sense of themselves as people who can and do make a difference, but using mathematics as a tool to support their actions challenged students’ view of the discipline. For instance, when we initially asked Naisha what she thought of mathematics, she responded, “What do I think of math—you mean, numbers?” She described math as something she felt good about only when she got the answers right.

In contrast, as Naisha reflected on Beatriz’s class at the end of the semester, she explained that unlike previous classes, where she studied material but never had the opportunity to “do anything” with what she learned, in this class, “we did something with it. ... Without the math, then, we wouldn’t have the area of the school, and we wouldn’t really know. And the [district] meeting wouldn’t have been as powerful as it was.”

Naisha was not the only student to begin to recognize that math “made [her] arguments make more sense.” Other students said math helped them

to “prove how most stuff is not shared evenly” and “to prove to the district that our school was smaller,” and that math “gave more details” and “specifics” to their arguments, and afforded them “more defense” in the problems they were fighting against. Students also spoke eloquently about how they drew upon mathematics to address “things in [the] community and school,” and referred to this way of engaging with the discipline as “a lifelong thing,” that is not only about mathematics but also about “things that you be in everyday, and it’s a part of your life.” Given that students often struggle to identify reasons why they should learn mathematics, these shifts in their understanding of the discipline are significant.

Further Reflections

As we reflected on the project, we found that creating spaces for students to pose their own problems and to inject their interests and concerns into the curriculum was a powerful way of supporting student activism. Occasionally, students posed problems about the school that did not lend themselves to rich mathematical investigations. We recognize that teachers have a responsibility to ensure that students learn certain content, and students’ interests may not always lead them to a given mathematical idea. Beatriz had clear mathematical goals in mind for this unit (linear and area measurement, ratio, operations with fractions, and mixed numbers). But she thought it was equally important that students participated in mathematics projects that were personally and socially meaningful. We acknowledge that mathematics may not always be the best discipline to address the questions that students pose. Beatriz’s challenge was to work with students to negotiate an intersection between their interests and the mathematical content they needed to study.

We also found that creating a class-

room culture where critique was welcomed, and even expected, was essential. It was important for students to feel safe posing difficult questions, such as those that alluded to the connection between their particular situation at Francis (a poor school, with inadequate space and resources), and broader educational inequalities that exist along the lines of race and class. While classroom discussions began with matter-of-fact statements about the data students were collecting, through questions such as, “Why do you think it is like that?” the talk gradually shifted to an exploration of why particular discrepancies existed, namely those between Francis and Longmore. Students argued that the superior conditions at Longmore were not random, but directly related to the race and socioeconomic status of the students. “There are more white people than anyone else at that school,” one student noted, and “the white people always get the good education, it’s like an upper-class thing, for the white kids. . . . That’s just how it is!” In further discussion, students suggested that the demographics (in particular, the socioeconomic status) of Longmore students were unlike those of Francis, and that these differences in demographics might be linked to the discrepancies in the condition and size of school facilities, and to the “protection” of the school by those in power.

Beatriz opened a space in her classroom for students to approach their situation with a critical mind-set, and in doing so, she supported their sense that they can act and make a difference.

At the end of the study, it was still unclear whether the district would increase the school’s allocated space or make any adjustment to the number of incoming students that Francis had to accept. So unfortunately, the students ended 6th grade not knowing whether their efforts had any direct impact. But over the summer, the district decided

to reduce Francis’ incoming class by approximately 30 students. This allowed the school to retain its current size of 213 students instead of increasing to 240 as initially planned. The district’s action prevented an already overcrowded school from growing, which students welcomed as one small success.

Yet, what seems most important is not whether this particular “battle” was won or lost, but the shifts in understanding and increased critical awareness that students took from the experience. As Jhana put it: “We found out something for ourselves, and we actually proved a point. We made a difference. Math made our argument make more sense. You couldn’t do it without the math.” ■

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