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Changing the Face of Math

Student perceptions may hold the key to mastering a "cold" subject

By LAURA PAPPANO

Jennifer Crump's students got fired up to study math by researching the question, "Are human beings proportional?"

What if our national problems with math—from poor school and test performance to the dearth of STEM grads—are more about fuzzy-sounding stuff like relationships, emotion, and identity than, well, actual math?

Don't laugh. Math education experts say we're in crisis and that traditional approaches of treating math like a cold-blooded subject amid the warm and engaging world of K–12 schooling are a big part of the problem. Narrow cultural beliefs about what math success looks like, who can be good at it, and what it's used for are driving students to approach the subject with timidity—or not at all.

"We have all these rules about how you are allowed to participate in math," says Rochelle Gutiérrez, professor of math education at the University of Illinois at Urbana-Champaign. "They are driven by, 'Can you replicate the procedure the people before you have come up with?'"

Unlike other subjects, such as English, in which teachers expect children who lack good spelling and grammar to imagine themselves as authors and poets and experiment with language, in math students aren't encouraged to be puzzlers and questioners, says Gutiérrez. Math instruction, she says, "asks you to forget being who you are so you can participate in this false reality."

The solution, according to Gutiérrez and others, is to change students' relationship to the school subject and help them build "math identities," make curricula more relevant, and recast our image of math success.

Changing the Definition of Success

Central to our math disconnect, say education experts, are misconceptions reinforced in classroom practice, including emphasis on finding "the answer"—fast.

"There is a culture of emphasizing efficiency in mathematics," says Osvaldo Soto, who coaches math teachers as field director of the San Diego chapter of Math for America. "Math problems do not all take five minutes to solve."

Not only does it lead students to disengage, but, Soto says, it also reinforces precisely the wrong habits of mind needed for success. Spending time "mucking around" and puzzling, trying ideas, making mistakes, and then trying different ideas are paths to developing skills in deductive reasoning and making and supporting an argument.

"That is one of the pillars of mathematics—the ability to reason from one point to another," says Soto, adding that tricks and

cutting to quick solutions cheat students of this learning.

The premium on speed shows up in timed tests, says Julia Aguirre, assistant professor of education at the University of Washington, Tacoma. Even those engaged in rich and valuable thinking may feel like failures when progress is cast as pushing through problems more quickly.

"De-identifying with Math"

This is exactly what Rachel Lambert, who just earned her Ph.D. from the Graduate Center at the City University of New York, found in research for her dissertation, in which she tracked nine Latino students through their sixth- and seventh-grade years, interviewing them and observing them in class and on videotape. Interestingly, in the midst of Lambert's second year of research, the classroom teacher, aware of state test results linked to teacher pay, shifted instruction from a discussion-based approach to test prep, from valuing thinking to prizing speed and memorization.

Lambert saw a profound effect on students' sense of what constituted "being good" at math. Those who had taken pride in contributions to discussions and their persistence lost standing among their peers in terms of how their math skills were perceived.

Even students good at memorization, she says, "talked about the anxiety they were feeling about mathematics." Several who had reported enjoying math found the subject "was no longer interesting to them as a person." Lambert concluded that several students were, in her words, "de-identifying with math."

While teachers imagine they are merely transmitting information, Lambert saw clearly that a teacher's words carry emotional meaning and form a student's relationship with the subject. Students, she says, "take all the words and practices seriously to make sense of themselves." They are constantly assessing—"Am I good at this? Does it matter to me?"—she says, adding that narrowing instruction "forced kids into a very rigid way of understanding themselves."

Even the marks on math papers send signals, says Aguirre, who notes that "the conventional wisdom is that we focus on errors." She asks, "What is the message they see when they see check marks? What does it do to their confidence when they see that?" Aguirre wants teachers to be more mindful of how they make corrections and note strong thinking even if the final answer is wrong. Teachers, she says, should ask, "How are we moving kids forward and giving them a sense of their mathematical progress?"

Building Emotional Bridges

In most academic subjects, researchers recognize that students must feel seen and heard to engage, says Eric Toshalis, assistant professor of education and counseling at Lewis & Clark College in Portland, Ore. In math, however, teachers have not traditionally considered "whether the math student feels known, feels affirmed and understood," he says. "For a lot of math and science teachers, this is not their strength. They have been taught to be such content masters."

It may feel counterintuitive, but math teachers need to connect emotionally with students to help them "see their role and power," says Kasi Allen, associate professor of math education at Lewis & Clark College. That can mean uncovering the baggage a student carries. "They come to the classroom with a mathematics identity, and by the time they get to high school that identity is known by their peers. You are math able or you are not."

Allen says teachers gain by learning the source of students' feelings about math, including how their identities are shaped by community and family attitudes. "There is no other subject where parents come to you and say, 'Don't be too hard on our kid; we suck at math in our family,'" she observes. It's also problematic for black and Latino students that math is cast as a white and European activity. "Our black students don't have any sense that there are black folks who have contributed or aren't even aware that powerful mathematics have come out of Egypt."

Yet, she says, we can change the way we talk about math to make it more inviting for more students. We can share, for example, that algebra is only about 400 years old and is something humans invented. It is also dynamic and not static and is supposed to push us to think more deeply, she says, and not to memorize large stores of facts.

Making Math Useful

In forging connections between students and math, it's helpful to consider two key aspects, says Erin Turner, assistant professor at the University of Arizona College of Education. First, she says, students must see themselves as having knowledge, skills, and experience they can bring to classmates and to specific problems.

"The other part is how do students see themselves using mathematics inside and outside of school?" she says. "Do they see mathematics as playing a useful role in their community to achieve goals—not just academic goals, but in their lives?"

Gutiérrez says one of her frustrations is that math problems cast as real-world puzzlers are often anything but. That is why math education experts love problems that come directly from their schools and communities. Which laundromat has the best deal for a family with five loads of clothes? Is the school overcrowded? Are Latino students disproportionately the subjects of school suspensions? (See sidebar "Who's Doing the Math?").

Who's Doing the Math?

"Who's doing the work?" That's the first question Kasi Allen, associate professor of education at Lewis & Clark College, asks when she visits a math class. Putting work in the hands and minds of students, instead of the teacher, is essential, but it means shaking up the traditional lesson. Here are three tools to connect students with math learning.

• *Flip the chapter*. Osvaldo Soto, a field director for Math for America who also teaches math at Patrick Henry High School in San Diego, says too many textbooks start with basic problems that encourage learning tricks, before understanding the big idea. His solution? Flip the chapter. He starts with the tough questions at the back so students get to discuss and puzzle over them. "They need to understand the problem," he says. "The solution is bothersome when there is no problem."

• *Math gallery*. If you walk into Kemble Schnell's seventh-grade algebra class at Wood Middle School in the West Linn-Wilsonville School District in Oregon, you might see giant sheets of sticky-note paper on walls and students gazing at them as if in a museum. What they puzzle over and take notes on are math problems worked out by their peers in groups. "They walk around and make observations," says Schnell, adding that she asks them to jot down four things they notice, three things they wonder about, and two things they understand. This is the starting point for "the math conversation piece," the class discussion she finds critical to math learning.

• *Projects from life*. Jennifer Crump, who teaches seventh- and eighth- grade math at First Creek Middle School in Tacoma, Wash., hasn't used a textbook once this year. Her classes cover concepts through projects she devises based on getting to know students and "things they think would be interesting." This past winter, her seventh-graders puzzled over proportion by investigating body image. They began by wondering how GI Joe and Barbie compared to real humans. (They were surprised to learn they're not very realistic, she says.) They also considered their own height and arm ratios, pored over those same stats for professional basketball players, and, she says, even "found a boxer who had a really long arm span [in proportion] to his height." This approach to teaching math, she says, has students fired up. "They come into class really excited and ready to go."

Turner says one example that made this connection for students happened in an afterschool program in which upper elementary students visited an auto body shop that converts cars to lowriders. Key to the work is the art design, so students interviewed the artist and the mechanic. They learned about the math involved in scaling small designs up to fill the hood of a car, measuring the hood space, and estimating the paint needed. Students then created lowrider designs and worked through the same math as the body shop designers.

More Thinking, Less Doing

Getting students to see math not as disconnected numbers but as tools to express ideas is at the heart of an approach to geometry called Conversations with Euclid, created by Guershon Harel at the University of California, San Diego. Last

summer Jannelle Olivier, who teaches math at Olympian High School in Chula Vista, Calif., and is a Teaching Fellow in the Math for America program, participated in Harel's workshop and was so taken with it that last fall, in a kind of grand experiment, she decided to try it in her classroom.

The approach asks students to explain aspects of human life to an intelligent alien named Euclid. Class, in other words, is nothing like the lesson-practice-correct-new-lesson cycle of learning. Instead, students debate answers to questions such as:

- What are the most basic physical objects of our surroundings?
- What is a useful way to imagine these objects when we do math?
- How can we share with Euclid the way we think of these objects when we do math?

Homework requires reflection. A typical assignment, says Olivier, might be: "I would like you to summarize RJ and Leah's thinking today." At first, she admits, "the kids were frustrated, asking, 'What do you mean, [Euclid] doesn't know?'" But then it clicked. Students engaged.

And, most tellingly, they learned. What struck Olivier was how the data on her students' performance compared with those of their peers in a traditional geometry class. When students were given quarterly assessments, Olivier's students had covered material for just 29 out of 45 of the test questions but still outperformed students in traditional geometry. In the midyear end-of-course exam, given to all students in the district, the 187 students in her Euclid courses outscored the 180 students in regular classes on nine of 13 content standards, earning on average 61 percent correct compared with an average score of 55 for peers in traditional courses and 52 percent in the district.

"I discovered less is more," she says. When she surveyed students about the experience, she found that 78 percent preferred the approach to traditional lessons, 74 percent said it improved their intellectual perseverance, and 83 percent agreed it boosted their deductive reasoning skills.

It may seem counterintuitive for math class to be about debate and conversation—and it may require more teacher energy to pull it off—but Olivier is sold. "Overall, I am a happier teacher teaching this way," she says. "They are questioning more, and that's where I get my satisfaction. They are problem-solvers, not just answer-getters."

Education journalist Laura Pappano is a regular contributor to the Harvard Education Letter.