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Closing the Math Achievement Gap

EDITOR'S NOTE

Math proficiency is critical to students' logical and analytical thinking. This Spotlight will help you gain real insights into changing students' perspective of math; learn how to transform professional development and instruction for math teachers; investigate how to use real-world problems to improve math instruction; explore how educators can support students with math anxiety; dive deeper into possible strategies for improving math education; and more.

OPINION

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Making Math Matter: A District Leader's Mission

By Sarah Schwartz

Tonya Clarke has always loved math. But the students she taught during her first year in the classroom 25 years ago decidedly did not.

The class of juniors and seniors in Georgia's Clayton County public schools had been told they weren't on a college track. They couldn't see how the problems in the textbook would be relevant to their lives.

"That was not something they prepared me for when I graduated from Georgia State," said Clarke, now Clayton's K-12 math coordinator, of the institution where she earned her teaching degree. "They did not tell me that students would not like math."

So she made it her mission to change their minds.

Instead of assigning her students a list of problems from the textbook, she asked them to do a set of calculations that she knew they would care about—to run the numbers on their future lives. What were they planning to do for a living? How much would it pay? How much would housing, food, other expenses cost? The budgeting project achieved what she'd set out to do: Show her students why math was useful in the real world.

It's a goal that's driven her work ever since.

"I had to figure out how to get the students to understand it and enjoy it. And that challenge was addictive: What else can I get them to enjoy?" Clarke said. "For me, it's still the part that I love about education as a whole. There's always something to problem-solve, to think through. There's always a challenge."

When Clarke, 53, started as the district's math coordinator, in 2014, she had her most high-profile opportunity yet to "make math matter" for students across the district, just as she had in her own classroom years ago.

It became her slogan, her guiding star.

Clarke has set a vision for all students to think, reason, and analyze in math class, not just memorize equations. A few years after she started in the role, she began to build a new system to teach teachers how to facilitate this in their classrooms. And she's brought in partnerships that expand students' extracurricular options in math and give them opportunities to see themselves as leaders who can use math to solve real-world problems.

—Dustin Chambers for Education Week

Tonya Clarke, coordinator of K–12 mathematics in the division of school leadership and improvement for the Clayton County Public Schools in Jonesboro, Ga., helps students with geometry while observing an 8th grade math class at Adamson Middle School late last year.

It's a demanding approach to teaching an already challenging subject in a school system where Clarke says many educators believe that teacher-led instruction is key to creating an orderly classroom and a calm learning environment. Giving students more control in the problem-solving process can feel risky and unpredictable.

But Clarke not only believes her students can handle a deeper approach to math, she also wants them to understand that developing perseverance—in math classes and outside them— can change their lives. It's a goal that's especially important to her as a Black educator, working in a majority-Black school district, she said.

About 70 percent of Clayton County students are Black; 22 percent are Hispanic. Nearly half of all students are economically disadvantaged, as designated by the state. Math-test scores were already well below the state average before the transformation began.

Clarke wants Clayton's students to have access to math-based careers and to be able to use math to change their own communities.

"So much is going to depend on them having the knowledge and the wherewithal to advocate for themselves," she said.

Still, she's quick to say that the work is only beginning. While she's seen some classroom-level change in how students reason and discuss, new teachers are hesitant to deviate from a lecture-based format. State test scores, in part a casualty of the pandemic, haven't yet shown gains.

But her colleagues across the district say that she's shifted the conversation about what math is for and what Clayton's students are capable of.

Through her more than two decades in the district, Clarke has built a reputation for setting ambitious goals and working shoulder to shoulder with teachers to attain them.

Clarke is asking for a big change from teachers, said Catherine Lawrence, a math and science instructional-support teacher at Adamson Middle School, but at the same time, she conveys the message, "you're not alone."

The 'I'm W.O.K.E. Project'

Though the effort has become districtwide, Clarke started small, gathering a few teachers who were enthusiastic about embracing a project-based approach to math. They launched a pilot program in the 2016-17 school year.

At the time, Clarke said, students in the district closely followed conversations about police shootings and conduct. She and the teachers searched for a related topic that they could examine through data—and landed on New York City's stop-and-frisk policy.

The pilot ran as a four-week Saturday school course with middle and high schoolers. Instead of solving a series of equations, students spent their lessons comparing arrests by geographic area using ratios and proportions and graphed data to paint a picture of the overall impact of the program.

About 20 kids showed up to the first session, mostly students who wanted—or needed—the extra credit that teachers offered for participation to boost their grades. The second week, the size of the class had swelled to more than 30.

"The students who came the first week went back and told other friends about this project that we were doing that was going to help them examine fair policing," Clarke said. "And they brought more students with them."

Clarke dubbed this project-based structure the "I'm W.O.K.E. Project," an acronym for Widens Options through Knowledge and Empowerment. It's since morphed into a one-week special project for middle schoolers for three academic years running. And it laid the foundation for the kind of professional learning she focuses on in her role as math coordinator.

"What we've been trying to get [teachers] to understand is start with the project," Clarke said. "Start with the students and their interests; start with, 'What will capture them?' And then let's look for where is the math within that? And how can we pull that math out?"

That doesn't mean projects for projects' sake, she cautioned. Teachers would still need to teach to the standards and cover grade-level content. But they would meet those goals through students' interests. Along the way, students would problem-solve, discuss their ideas with peers, and explain their reasoning.

That would take planning and deep content knowledge on the part of educators. It would mean teaching teachers to work in a dramatically different way from what they were doing at the time.

But Clarke thought it was the only way forward.

"There's no problem that you can't figure out," she said, an adage she adopted from her late father.

Neither of Clarke's parents finished high school, but both went back to get GEDs and post-secondary degrees as adults. Watching them build successful careers—her mother as a nurse, her father as a small business owner—helped her envision big possibilities for herself, and later, for her students.

> "Start with the students and their interests; start with, 'What will capture them?' And then let's look for where is the math within that? And how can we pull that math out?"
>
> **TONYA CLARKE**
> K-12 Math Coordinator,
> Clayton County, GA

'The things I saw her do, I mimicked'

Clarke's approach to teaching math isn't unique. Showing the subject's real-world relevance and asking students to reason and discuss in math classes are strategies embedded in many materials designed to meet the Common Core State Standards.

They're also central to California's new proposed math framework, which has stirred up discussion and debate in the field. Over the past few years, more teachers have designed projects that ask students to use math to investigate social and political issues.

But applying this idea well is hard. It requires careful sequencing and teacher-provided support to make sure students have the content knowledge and procedural fluency they need to reason through complex problems.

"Problem-based structure has never been widely adopted in the United States. The further you go up [the grade levels], the less likely it's going to happen," said Andrew Brantlinger, an associate professor of mathematics education at the University of Maryland.

There's a lot to cover in math standards, in part because higher-level math is seen as central to college- and career-readiness. Taking the time for students to work through a problem can feel like an unnecessary detour for teachers facing pressure to race through content, he said.

Compounding matters: Most U.S. teachers didn't learn math this way. In order to do problem-based learning well, teachers need to be "flexible in [their] knowledge," Brantlinger said—able to adjust if students' questioning leads in unexpected directions.

Teaching teachers how to do this, and ensuring they have the background knowledge necessary, is difficult for most districts that try this approach, Brantlinger said.

"What's happening in Clayton, it's a national issue," he said. But Clarke is unique in one way, Brantlinger said: Her long-standing commitment to the district, her being "rooted in the community."

Clarke has used the capital she built up through more than two decades in Clayton in part to focus hard on teacher training. Her team has embedded new activities into the district curriculum, math tasks that provided opportunities for discussion and reasoning. But they knew that curriculum alone wouldn't bring about changes in instruction.

Giving teachers the chance to learn new approaches, test them out, and discuss with one another—that wasn't going to happen at a one-off professional development session. So Clarke created a cadre of math ambassadors: classroom teachers, at each school and every grade level, who could meet with her regularly, learn together, and then mentor their peers.

For some teachers, taking on the role felt like an extension of the mentorship that Clarke had already been doing more informally with them throughout her two decades in the district.

"The things that I saw her do, I mimicked," said Lawrence, the instructional-support teacher. Her education in Clarke's methods started long before her teaching career; back in 12th grade, she was one of Clarke's Algebra 3 students.

"In her class, I was able to ask 'why' and actually get a definitive answer," Lawrence remembered—a contrast to other math classes she had been in where questions about the 'why' behind math methods "were just met with resistance." Clarke matched students with a peer partner to discuss and problem-solve. Lawrence instituted the same system in her own classes when she became a teacher.

Tarquiann Bates, an Algebra 1 teacher at Morrow High School, also remembered borrowing from Clarke's approach for his own classroom, even before he started working as a math ambassador. "She's definitely leading from the front," he said.

Still, he worries about maintaining buy-in among staff. It takes a while to bring teachers

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>
> **CATHERINE LAWRENCE**
> Middle School Math and Science Teacher,

around to this approach, he said. When teachers leave, or new staff starts, that process has to start all over again.

Encouraging students—and teachers—to notice and wonder

Clarke understands that getting teachers on board takes time. Giving up any control in a room full of 20 to 30 teenagers is intimidating. Teachers worry that if they're not "the meanest or the sternest," kids will lose focus or end up off task. But lecturing to prevent side chatter doesn't reliably engage students, either, she said. So Clarke tries to show teachers how to strike a balance.

In monthly meetings with the district's math ambassadors, she models new procedures. Take one example of a 3rd grade lesson on symmetry.

Typically, teachers start by defining the term. In Clarke's model, teachers begin by showing images that lack symmetry, a photo of a crab with three legs on one side and four on the other, for instance. They ask: "What do you notice, what do you wonder?"

Once the students identify the leg difference, teachers can connect the concept of symmetry to an understanding that students already had.

The goal is for math ambassadors and other coaches to spread these practices to the teachers they work with. So far, though, that's been a challenge.

Many teachers haven't had much guidance with the new methods in part because school leaders haven't made it a priority to schedule time for math ambassadors to offer training and group planning, Clarke said. She and her team are still working to change that, despite competing demands for teachers' time during the day.

Clarke believes these implementation problems are part of the reason the instructional changes haven't improved students' math scores on state tests.

Like other high-poverty districts, Clayton has long struggled with the subject. Only 17 percent of students scored "proficient" or above in Algebra 1 on state end-of-course assessments, compared with about 36 percent of students statewide, on tests administered in spring 2016, the year before the math transformation began.

Despite the efforts of Clarke and her team, those Algebra 1 scores haven't budged. In fact, they fell: Just 14 percent of students scored at the proficient or above level in spring 2022—the first normal year of testing during the pandemic.

Still, schools are seeing some early evidence that they're on the right track.

The district is also tracking student interest, said Trina Reaves, Clayton's director of STEM (science, technology, engineering, and math) and innovation.

Clarke set up new districtwide math competitions in which students demonstrate mathematical concepts through art, design their own math board games, or work in teams to use math to solve a real-world problem. Pre-COVID, about 600 students a year participated—a six-fold increase from the number that used to participate in the district's exam-based competition.

Clarke has also struck up partnerships with several outside organizations to bring math-enrichment opportunities to district students, Reaves said.

One of the students who participated was Anna Njie.

Now a freshman at Vanderbilt University, Njie spent the summer of 2020 teaching elementary and middle school students remotely as one of Clayton's math-literacy workers—an internship for high schoolers to teach math to younger children, which Clarke brought to Clayton through a partnership with the nonprofit Young People's Project.

The program changed how Njie thought of herself: as someone who had something to teach others. She attributes much of that change to the leaders of the program, including Clarke.

Clarke made it known, Njie said: "What we had to say mattered." ■

—Dustin Chambers for Education Week

Tonya Clarke, coordinator of K–12 mathematics in the division of school leadership and improvement for Clayton County Public Schools in Jonesboro, Ga., believes in using real-world problem-solving to teach math.

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What Professional Development For Math Teachers Should Look Like

By Sarah Schwartz

Tonya Clarke's vision for math instruction in Georgia's Clayton County public schools sounds simple: She wants students to think, reason, and analyze in order to solve real-world problems. But putting that vision into practice is more complicated.

It requires a shift in how teachers plan instruction—focusing on giving students opportunities to problem-solve and discuss different strategies for achieving the same answer, while integrating more project-based learning.

One key component of this shift has been the creation of a team of math ambassadors: teachers who receive training from the district and then mentor teachers in their buildings. Clarke, the district's K-12 math coordinator, spoke with Education Week about her approach to teacher professional learning and creating districtwide buy-in for instructional change.

This interview has been edited for length and clarity.

How do you help teachers learn and develop in doing that kind of work—helping students become problem-solvers?

The math ambassadors is one way that we are ensuring that there's some kind of job-embedded support that every teacher has when they're planning.

It's an opportunity to brainstorm, to think through strategies, to engage in them yourself. When you come back to your building, not only have you thought about strategies for an upcoming unit, but you've also had a chance to engage in what a collaborative planning session should look like. So that way, you can also facilitate more meaningful and effective project planning [with teachers].

Does what teachers need vary building by building? How do you tailor district support?

We have personalized school improvement plans that we developed for each school. We meet with each administrative team and their teachers at the beginning of the school year and talk about what are their goals for this year. Where would they like to be? What are the areas that we need to focus on? We develop a plan specifically for that building.

There are some schools that [my team is] in every other week, every week, and then there's some schools that they're in a couple of times a month. And then there are some schools that we just touch base with, either virtually, or we're connecting with them through the lead teacher or ambassadors, but we're not necessarily in their buildings consistently unless there's something specific they need.

What are the challenges you're still experiencing?

Our scores are still not showing the results we are looking to see in the classroom.

As a district, those are things that we're working on—to connect better from instruction to leadership, to make sure that what we know needs to happen with instruction is actually being implemented and implemented with fidelity.

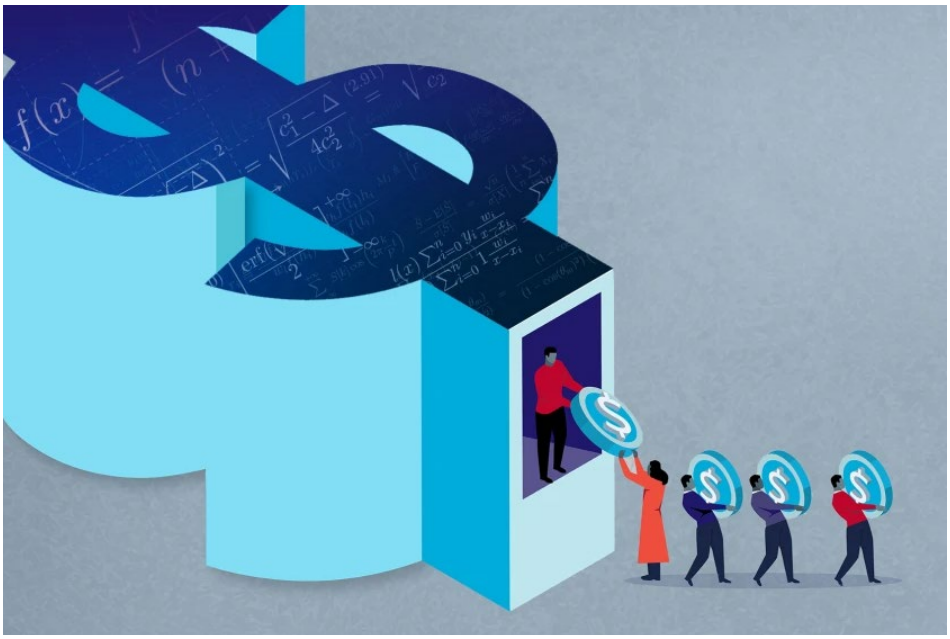
We're preparing ambassadors to support the collaborative planning. But if there's not a structure in that building to ensure that teachers are getting consistent, undisturbed collaborative planning time, that part is not even going to be implemented in the building.

What advice would you have for other district leaders who are responsible for creating and implementing a vision for math education?

Really think about how you can bring as many people as you can in. Instead of me trying to train everyone, how do we break this into smaller pieces, into smaller groups, and manage those smaller groups?

Don't be afraid to bring in other departments that can help you build up in other areas that are just not your background.

I've had to bring in the ELA department to help us with how do we teach language in the math department. Language development is not our background and especially at the secondary level. So we've had to do some training on how do you teach vocabulary in a way that's meaningful. We've learned a few things, at least about the science of reading, to be able to help students that are essentially nonreaders or who are really struggling with decoding: How do I get them, as a math teacher, to at least be able to read the passage? ■



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How Would Teachers Spend the Gates Foundation $1.1 Billion Investment In Math?

By Alyson Klein

The Bill & Melinda Gates Foundation announced this month that it will be pouring $1.1 billion over the next four years into improving math teaching and learning, the start of what could be a decade-long investment in math education.

The timing is resonant: Results from the most recent National Assessment of Educational Progress showed that student performance in math cratered, erasing two decades of progress.

The foundation has been conducting a yearlong listening tour, reaching out to educators, researchers, and communities, and has pledged to continue doing so. (The Gates foundation provides sustaining support to Editorial Projects in Education, the publisher of Education Week. The media organization retains sole editorial control over its articles.)

How would veteran math teachers, district leaders, and principals spend $1.1 billion to strengthen math instruction, if it were totally up to them?

Here's what they said:

Robbi Berry, elementary school teacher in Las Cruces, N.M.,

Wants: Materials for inquiry-based math instruction.

Berry is a proponent of using real-world problem solving to teach math. "The focus really should be inquiry based hands-on, with kids questioning and doing. That's how they learn, not memorizing rote procedures and just practicing step one, step two, etcetera," Berry said in an email. "I'm not saying we don't do practice for procedure and fluency, but there needs to be a balance."

She would love to see the money go toward "tools that allow students to do hands-on math via project-based learning. Sadly, there are schools that don't even have manipulatives. Which is a significant headwind to both individual learning and community equity."

Donna Hayward, principal of Haddam-Killingworth High School in Higganum, Conn.

Wants: Math intervention specialists and professional development.

"My answer is really more, more instructional staff and specifically, trained instructional staff," Hayward said.

Her reasoning: Unlike in most other subjects, math requires students to be developmentally ready to tackle certain concepts, she said. Because students develop at different rates, one 8th grader could dive into abstract concepts and algebra, while another may need to wait until 10th grade to tackle those skills, she explained.

Trained intervention specialists with a background in math and special education could target "[students] when they're ready" to learn a particular concept, Hayward said. Such specialists could also fill in the gaps in students' knowledge because "even if their brain has developed to the point that they can understand an abstract concept, if they don't have all the prerequisite knowledge, they're not going to get it. They just don't have a foundation on which to build it."

She would also provide "real, targeted professional development for all teachers. ... Who doesn't need new tools in their toolbox?"

Latrenda Knighten, a mathematics instructional coach in Baton Rouge, La.

Wants: Ongoing support for teachers.

Knighten likes the idea of grounding teachers in engaging, research-based math instruction. But that professional development can't be a one-time thing, she said.

"You wouldn't teach something to kids just one time and expect them to be an expert," she said. It's the same with teachers. "You go back, you practice, and you practice." She would create communities of educators who could learn together, reflect on their work, swap ideas. And she'd add coaches: "Not just a generic coach, a math instructional coach, someone who is grounded in those practices that you want to see in the classroom."

Teachers would really benefit from having "boots on the ground support"—someone who could help them troubleshoot or teach a demonstration lesson, Knighten said. "We have to train a cadre of teachers so that they feel comfortable that they're able to provide instruction based on the best practices we've known for years."

David Schexnaydre, principal of Harry Hurst Middle School in Destrehan, La.

Wants: Instructional materials, curriculum, professional development, all vetted by educators.

Schexnaydre said he would create mate-

rials, professional development, and curriculum, getting input from teachers and administrators at every point in the process.

"Obviously, you need engaging lessons. You need a strong curriculum. Kids want to be able to apply their learning to real-life situations, which I think is probably one of the weaknesses of some our math [materials] right now. Like, how often does the kid ever have to go outside and find X?" he said, referring to variables in an algebraic equation.

But teacher training will be key, he added. "It really comes down to the type of embedded, ongoing high-quality professional development we give teachers so that they're able to do this at a good level and really build the conceptual understanding for [students.]"

Bobson Wong, New York City math teacher

Wants: Smaller classes and resources for teachers to do the administrative parts of their job so they can focus on instruction.

Wong would like more-effective tools to help with tasks that take his focus away from teaching. "I don't have grading or attendance software that really works for me, because it's not built for teachers. I don't have the ability to send text messages to parents and have them respond to me on their cellphones. The platforms that are out there are really not very good. And they're really not designed for teachers." He's also interested in software to help students get more practice with math concepts.

The other big thing on his wish list? Reducing class size. Wong has "34 students in a class for five classes a day," and just 45 minutes a day to prepare his lessons, he said. "If I had 15 kids in that room, I could do so much more." ■

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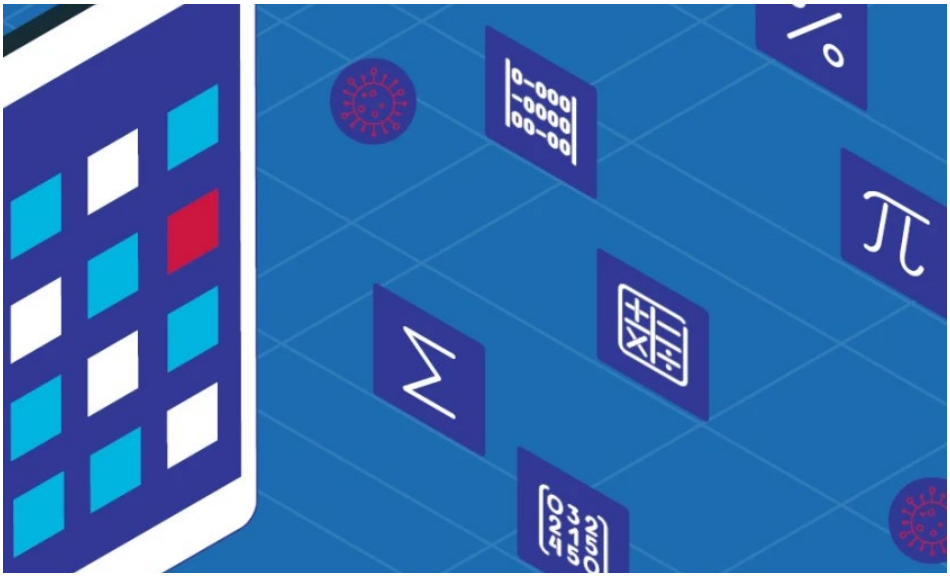
How to Use Real-World Problems to Teach Elementary School Math: 6 Tips

By Alyson Klein



—Vanessa Solis/Education Week and Getty

When you think back on elementary school math, do you have fond memories of the countless worksheets you completed on adding fractions or solving division problems? Probably not.

Researchers and educators have been pushing for years for schools to move away from teaching math through a set of equations with no context around them, and towards an approach that pushes kids to use numerical reasoning to solve real problems, mirroring the way that they'll encounter the use of math as adults.

The strategy is largely about setting kids up for success in the professional world, and educators can lay the groundwork decades earlier, even in kindergarten.

Here are some tips for using a real world problem-solving approach to teaching math to elementary school students.

1. There's more than one right answer and more than one right method

A "real world task" can be as simple as asking students to think of equations that will get them to a particular "target" number, say, 14. Students could say 7 plus 7 is 14 or they could say 25 minus 11 is 14. Neither answer is better than the other, and that lesson teaches kids that there are multiple ways to use math to solve problems.

2. Give kids a chance to explain their thinking

The process you use to solve a real world math problem can be just as important as arriving at the correct answer, said Robbi Berry, who teaches 5th grade in Las Cruces, N.M. Her students have learned not to ask her if a particular answer is correct, she said, because she'll turn the question back on them, asking them to explain how they know that it is right. She also gives her students a chance to explain to one another how they arrived at a particular solution, "We always share our strategies so that the kids can see the different ways" to arrive at an answer, she said. Students get excited, she said, when one of their classmates comes up with an approach they never would have thought of. "Math is creative," Berry said. "It's not just learning and memorizing."

3. Be willing to deal with some off-the-wall answers

Problem solving does not necessarily mean going to the word problems in your textbook, said Latrenda Knighten, a mathematics instructional coach in Baton Rouge, La. For little kids, it can be as simple as showing a group of geometric shapes and asking what they have in common. Students may go off track a bit by talking about things like color, she said, but teachers can steer them towards thinking about things like how a rectangle differs from a triangle.

4. Let your students push themselves

Tackling these richer, real-world problems can be tougher than solving equations on a worksheet. And that is a good thing, said Jo Boaler, a professor at Stanford University and an expert on math education. "It's really good for your brain to struggle," she said. "We don't want kids getting right answers all the time because that's not giving their brains a really good workout." These types of problems require collaboration, a skill that many don't associate with math, but that is key to how math reasoning works beyond the classroom. The complexity and difficulty of the tasks means that students "have to talk to each other and really figure out what to do, what's a good method?"

5. Celebrate 'favorite mistakes' to encourage intellectual risk taking

Wrong answers should be viewed as learning opportunities, Berry said. When one of her students makes an error, she asks if she can share it with the class as a "favorite mistake." Most of the time, students are comfortable with that, and the class will work together to figure how the misstep happened.

6. Remember there's no such thing as a being born with a 'math brain'

Some teachers believe that certain students are just naturally good at math, and others are not, Boaler said. But that's not true. "Brains are constantly shaping, changing, developing, connecting, and there is no fixed anything," said Boaler, who often works alongside neuroscientists. What's more, many elementary school teachers lack confidence in their own math abilities, she said. "They think they can't do [math]," Boaler said. "And they often pass those ideas on" to their students. ■

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Published March 31, 2022

Math Anxiety Weakens How Students Study. Here's What Teachers Can Do

By Sarah D. Sparks

Math anxiety doesn't just make students choke on tests. It changes their approach to learning the subject in ways that sets them up for ongoing failure.

A new study in the *Journal of Experimental Psychology* suggests math-anxious students choose less-effective ways to study, like rereading textbooks instead of working through real problems. This, in turn, can make them less prepared for exams and heighten the risk students will also "freeze" on the math test itself.

"The anxiety that happens in the moment [is] really robbing you of the ability to focus and do your best, and that's one of the reasons why math anxiety was often related to poor performance. But we knew that wasn't the whole story," said Jalisha Jenifer, lead author of the study and postdoctoral research fellow at Barnard College of Columbia University. "Now we're able to start pinpointing the way in which highly math-anxious people also ... walk in less prepared."

While students who are initially low-performing are also at higher risk of developing math anxiety, the study focused on students in Advanced Placement calculus courses. Even among these students, whose placement put them above average performance in math, those with high math anxiety were less likely to study efficiently than students with low levels of anxiety about the subject.

For example, researchers found math-anxious students dedicated more time to passive activities like reading their textbooks or looking at already-solved problems—which prior research has found tends to make students think they understand more than they actually do about content. By contrast, they spent less time actually practicing math skills.

"Solving math problems can help you to understand where gaps may be in your knowledge; you may not notice those things if you're just *reviewing* practice problems," Jenifer said. "Without challenging yourself in those ways ... you may never practice in the ways that you need for the exam."

—iStock/Getty Images Plus and Gina Tomko/Education Week

> "One of the reasons that anxiety tends to be correlated with poor performance is that anxiety pushes people to not engage in study material in a way that's efficacious."
>
> **SIAN BEILOCK**
> Math Anxiety Researcher,
> Barnard College, NY

Pandemic may have heightened math anxiety risk

The findings suggest that focusing on explicit study and anti-anxiety strategies may be critical for educators working to catch up students who lost significant ground in math during the disruptions of the last two years. General anxiety has increased for students during the pandemic, and "it's reasonable to expect increased levels of anxiety around math, especially if [students are] getting signals that you're not where you should be, that you're behind," said co-author Sian Beilock, math anxiety researcher and president of Barnard.

The vast majority of Americans report at least some levels of discomfort with math, and about a third report moderate to severe anxiety about the subject. More than 25 years of research suggests math anxiety can begin in the early elementary grades, but increases through middle and high school, particularly for students in groups stereotypically considered lower performers in math, such as women.

"Math may be a microcosm for what could play out in other areas," Beilock said in an interview. "So if you have anxiety about biology or some other subject you're taking, I think what we're showing here is, one of the reasons that anxiety tends to be correlated with poor performance is that anxiety pushes people to not engage in study material in a way that's efficacious."

In fact, a 2021 study in the journal Nature: Science of Learning found incoming college students with high math anxiety took fewer science, technology, engineering, and math classes, and underperformed in the ones they did take, compared to more-confident students with the same ability in math. Researchers led by Georgetown University psychologist Richard Daker concluded, "Math anxiety can account for associations between math ability and STEM outcomes, suggesting that past links between math ability and real-world outcomes may, in fact, be at least partially explainable by attitudes toward math."

Simple changes can help math-anxious students

In a 2020 survey, 67 percent of teachers told the EdWeek Research Center that math anxiety was a challenge for their students. But Jenifer and Beilock said simple changes before and during testing can boost students' confidence and performance.

As students prepare for a math test, Beilock said it's important for teachers to explicitly describe what makes study methods effective or not.

"I don't think people are always aware

that their study strategies are ineffective and what might be pushing them in different ways," Beilock said. "This research shows that there is a tendency for people who are anxious to stay away from more-difficult problems or more-effortful problems during practice—and just knowing that could push you in the opposite direction."

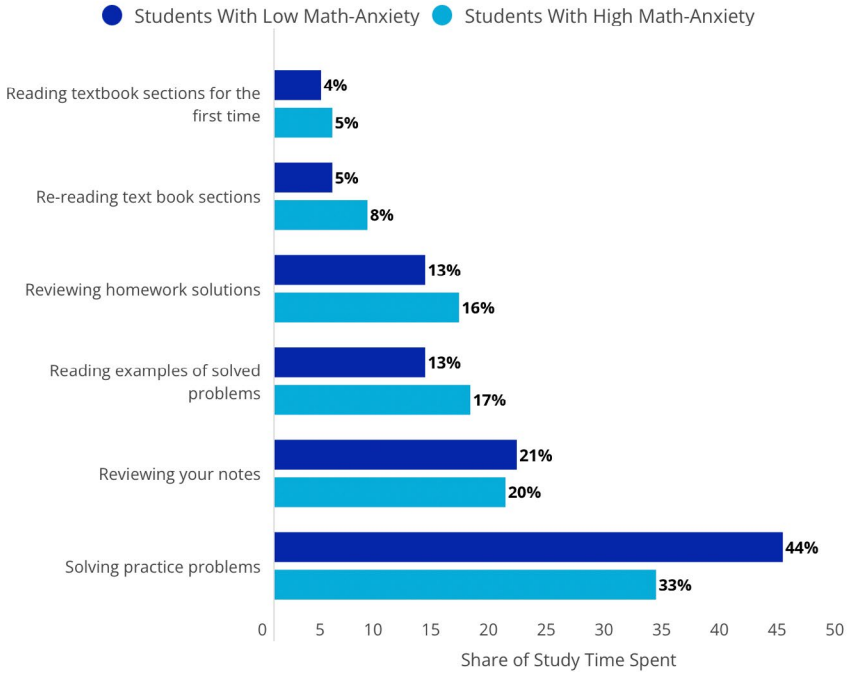
Teachers can help math-anxious students learn to study more effectively by providing both partially worked and unworked practice problems for review, which Jenifer said can ease students into practice. Similarly, teachers can give students more confidence to tackle challenging problems by asking students to solve them as part of games or puzzles, rather than for grades or homework.

On the day of a test, research suggests teachers can also help students reframe their physical symptoms of anxiety—such as sweating palms or a racing heartbeat—as signs of excitement or readiness. This reframing has been shown to help students avoid "choking" on exams.

Over time, helping anxious students learn to prepare more effectively and calm their anxiety in the moment can improve their math performance and help them gain more confidence in math—and even make them more likely to choose math and science work on their own. ■

Here's How Test Prep Changes When You're Worried About Math

Students with math anxiety consciously or unconsciously avoid active problem-solving, according to new Barnard College research published in the Journal of Experimental Psychology. That changes how they prepare for tests.



SOURCE: "Effort(less) Exam Preparation: Math Anxiety Predicts the Avoidance of Effortful Study Strategies," Journal of Experimental Psychology-General.

OPINION

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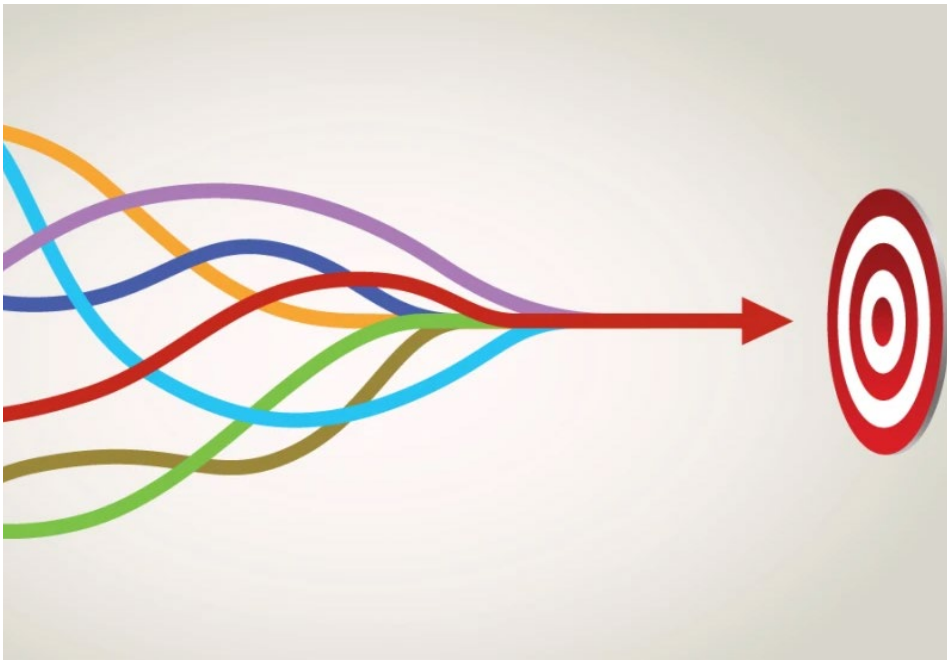
What It Takes to Actually Improve Math Education

By Rick Hess



—DigitalVision Vectors/Getty

Barry Garelick, a veteran math teacher in California and respected observer of math instruction, recently reached out after seeing my Q&A with ST Math's Andrew Coulson on using visualization to teach math. Garelick is a cogent thinker, clear writer, and author of books including Out on Good Behavior: Teaching math while looking over your shoulder *and* Math Education in the U.S.: Still Crazy After All These Years. *Given all that, I thought his reflections well worth sharing—see what you think. -Rick*

Rick, I thought your recent interview with Andrew Coulson of ST Math was a fascinating look at how educational products—particularly those that address math—are promoted. In the interview, Coulson states that the "innate ability of visualizing math was not being leveraged to solve a serious education problem: a lack of deep conceptual understanding of mathematics."

As someone who has been teaching math for the past 10 years and written several books on key issues in math education, this struck a chord for me. I've seen the three-decade-long obsession with "deeper understanding" cause more problems than it solves—including overlooking other factors contributing to problems in math education, such as the disdain for memorization, the difference between understanding and procedure, and the issue with trying to teach problem solving solely by teaching generic skills. Undoing these would be a long-overdue step in the right direction to reverse the trends we are seeing in math education.

For starters, many math reformers seem to disdain memorization in favor of cultivating "deeper understanding." The prevailing belief in current math-reform circles is that drilling kills the soul and makes students hate math and that memorizing the facts obscures understanding. Memorization of multiplication facts and the drills to get there, for example, are thought to obscure the meaning of what multiplication is. Instead of memorizing, students are encouraged to reason their way to "fluently derive" answers. For example, students who do not know that 8×7 is 56 may find the answer by reasoning that if 8×6 is 48, then 8×7 is eight more than 48, or 56. (Ironically, the same people who believe no student should be made to memorize have no problem with students using calculators for multiplication facts.)

> "I've seen the three-decade-long obsession with "deeper understanding" cause more problems than it solves—including overlooking other factors contributing to problems in math education."
>
> **BARRY GARELICK**
> Math Teacher,
> California

Unfortunately, this approach ignores the fact that there are some things in math that need to be memorized and drilled, such as addition and multiplication facts. Repetitive practice lies at the heart of mastery of almost every discipline, and mathematics is no exception. No sensible person would suggest eliminating drills from sports, music, or dance. De-emphasize skill and memorization and you take away the child's primary scaffold for understanding.

Teaching procedures and standard algorithms is similarly shunned as "rote memorization" that gets in the way of "deeper understanding" in math. But educators who believe this fail to see that using procedures to solve problems actually requires reasoning with such methods—which in itself is a form of un-

derstanding. Indeed, iterative practice is key to attaining procedural fluency and conceptual understanding. Understanding, critical thinking, and problem solving come when students can draw on a strong foundation of relevant domain content, which is built through the "rote memorization" of procedure. Whether understanding or procedure is taught first ought to be driven by subject matter and student need—not educational ideology. In short, of course we should teach for understanding. But don't sacrifice the proficiency gained by learning procedures in the name of understanding by obsessing over it and holding students up when they are ready to move forward.

Finally, although it's been shown that solving math problems cannot be taught by teaching generic problem-solving skills, math reformers believe that such skills can be taught independent of specific problems. Traditional word problems such as "Two trains traveling toward each other at different speeds. When will they meet?" are held to be inauthentic and not relevant to students' lives.

Instead, the reformers advocate an approach that presents students "challenging open-ended problems" (sometimes called "rich problems") for which little or no prior instruction is given and which do not develop any identifiable or transferable skills. For example, "How many boxes would be needed to pack and ship 1 million books collected in a school-based book drive?" In this problem, the size of the books is unknown and varied and the size of the boxes is not stated. While some teachers consider the open-ended nature of the problem to be deep, rich, and unique, students will generally lack the skills required to solve such a problem, such as knowledge of proper experimental approaches, systematic and random errors, organizational skills, and validation and verification. Students are given generic problem-solving techniques (e.g., look for a simpler but similar problem), in the belief that they will develop a "problem-solving habit of mind." But in the case of the above problem, such techniques simply will not work, leaving students frustrated, confused, and feeling as if they are not good at math.

Instead of having students struggle with little or no prior knowledge of how to approach a problem, students need to be given explicit instruction on solving various types of problems, via worked examples and initial practice problems. After that, they should be given problems that vary in difficulty, forcing students to stretch beyond the examples. Students build up a repertoire of problem-solving techniques as they progress from novice to expert. In my experience, students who are left to struggle with minimal guidance tend to ask, "Why do I need to know this?," whereas students given proper instruction do not—nor do they care whether the problems are "relevant" to their everyday lives.

At the end of the day, finding a cure for a system that refuses to recognize its ills has proved futile. Parents confronting school administrators are patronized and placated or told that they don't like the way math is taught because it's not how they were taught.

Change will not come about by battling school administrations. There must be a recognition that the above approaches to teaching math are not working, as is currently happening with reading, thanks to the efforts of people like Emily Hanford, Natalie Wexler, and others, who have shown that teaching reading via phonics is effective, whereas memorizing words by sight or guessing the word by the context or a picture is not. Until then, only people with the means and access to tutors, learning centers, and private schools will be able to ensure that their students learn the math they need. The rest will be left to the "equitable solutions" of the last three decades that have proved disastrous. ■

Barry Garelick *is a 7th and 8th grade math teacher and author of several books on math education, including his most recent,* Out on Good Behavior: Teaching math while looking over your shoulder. *Garelick, who worked in environmental protection for the federal government before entering the classroom, has also written articles on math education for publications including* The Atlantic, Education Next, Nonpartisan Education Review, *and* Education News.
Rick Hess *is a resident scholar and the director of education policy studies at the American Enterprise Institute. He writes the Education Week opinion blog "Rick Hess Straight Up."*

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