The case for 'math-ish' thinking

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For everyone whose relationship with mathematics is distant or broken, Jo Boaler, a professor at Stanford Graduate School of Education (GSE), has ideas for repairing it. She particularly wants young people to feel comfortable with numbers from the start—to approach the subject with playfulness and curiosity, not anxiety or dread.

"Most people have only ever experienced what I call narrow mathematics—a set of procedures they need to follow, at speed," Boaler says. "Mathematics should be flexible, conceptual, a place where we play with ideas and make connections. If we open it up and invite more creativity, more diverse thinking, we can completely transform the experience."

Boaler, the Nomellini and Olivier Professor of Education at the GSE, is the co-founder and faculty director of Youcubed, a Stanford research center that provides resources for math learning that has reached more than 230 million students in over 140 countries. In 2013 Boaler, a former high school math teacher, produced How to Learn Math, the first massive open online course (MOOC) on mathematics education. She leads workshops and leadership summits for teachers and administrators, and her online courses have been taken by over a million users.

In her new book, "Math-ish: Finding Creativity, Diversity, and Meaning in Mathematics," Boaler argues for a broad, inclusive approach to math education, offering strategies and activities for learners at any age. We spoke with her about why creativity is an important part of mathematics, the impact of representing numbers visually and physically, and how what she calls "ishing" a math problem can help students make better sense of the answer.

What do you mean by 'math-ish' thinking?

It's a way of thinking about numbers in the real world, which are usually imprecise estimates. If someone asks how old you are, how warm it is outside, how long it takes to drive to the airport—these are generally answered with what I call "ish" numbers, and that's very different from the way we use and learn numbers in school.

In the book I share an example of a multiple-choice question from a nationwide exam where students are asked to estimate the sum of two fractions: 12/13 + 7/8. They're given four choices for the closest answer: 1, 2, 19, or 21. Each of the fractions in the question is very close to 1, so the answer would be 2—but the most common answer 13-year-olds gave was 19. The second most common was 21.

I'm not surprised, because when students learn fractions, they often don't learn to think conceptually or to consider the relationship between the numerator or denominator. They learn rules about creating common denominators and adding or subtracting the numerators, without making sense of the fraction as a whole. But stepping back and judging whether a calculation is reasonable might be the most valuable mathematical skill a person can develop.

But don't you also risk sending the message that mathematical precision isn't important?

I'm not saying precision isn't important. What I'm suggesting is that we ask students to estimate before they calculate, so when they come up with a precise answer, they'll have a real sense for whether it makes sense. This also helps students learn how to move between big-picture and focused thinking, which are two different but equally important modes of reasoning.

Some people ask me, "Isn't 'ishing' just estimating?" It is, but when we ask students to estimate, they often groan, thinking it's yet another mathematical method. But when we ask them to "ish" a number, they're more willing to offer their thinking.

Ishing helps students develop a sense for numbers and shapes. It can help soften the sharp edges in mathematics, making it easier for kids to jump in and engage. It can buffer students against the dangers of perfectionism, which we know can be a damaging mindset. I think we all need a little more ish in our lives.

You also argue that mathematics should be taught in more visual ways. What do you mean by that?

For most people, mathematics is an almost entirely symbolic, numerical experience. Any visuals are usually sterile images in a textbook, showing bisecting angles, or circles divided into slices. But the way we function in life is by developing models of things in our minds. Take a stapler: Knowing what it looks like, what it feels and sounds like, how to interact with it, how it changes things—all of that contributes to our understanding of how it works.

There's an activity we do with middle-school students where we show them an image of a 4 x 4 x 4 cm cube made up of smaller 1 cm cubes, like a Rubik's Cube. The larger cube is dipped into a can of blue paint, and we ask the students, if they could take apart the little cubes, how many sides would be painted blue? Sometimes we give the students sugar cubes and have them physically build a larger 4 x 4 x 4 cube. This is an activity that leads into algebraic thinking.

Some years back we were interviewing students a year after they'd done that activity in our summer camp and asked what had stayed with them. One student said, "I'm in geometry class now, and I still remember that sugar cube, what it looked like and felt like." His class had been asked to estimate the volume of their shoes, and he said he'd imagined his shoes filled with 1 cm sugar cubes in order to solve that question. He had built a mental model of a cube.

When we learn about cubes, most of us don't get to see and manipulate them. When we learn about square roots, we don't take squares and look at their diagonals. We just manipulate numbers.

I wonder if people consider the physical representations more appropriate for younger kids.

That's the thing—elementary school teachers are amazing at giving kids those experiences, but it dies out in middle school, and by high school it's all symbolic. There's a myth that there's a hierarchy of sophistication where you start out with visual and physical representations and then build up to the symbolic. But so much of high-level mathematical work now is visual. Here in Silicon Valley, if you look at Tesla engineers, they're drawing, they're sketching, they're building models, and nobody says that's elementary mathematics.

There's an example in the book where you've asked students how they would calculate 38 x 5 in their heads, and they come up with several different ways of arriving at the same answer. The creativity is fascinating, but wouldn't it be easier to teach students one standard method?

That narrow, rigid version of mathematics where there's only one right approach is what most students experience, and it's a big part of why people have such math trauma. It keeps them from realizing the full range and power of mathematics. When you only have students blindly memorizing math facts, they're not developing number sense.

They don't learn how to use numbers flexibly in different situations. It also makes students who think differently believe there's something wrong with them.

When we open mathematics to acknowledge the different ways a concept or problem can be viewed, we also open the subject to many more students. Mathematical diversity, to me, is a concept that includes both the value of diversity in people and the diverse ways we can see and learn mathematics.

When we bring those forms of diversity together, it's powerful. If we want to value different ways of thinking and problem-solving in the world, we need to embrace mathematical diversity.

Provided by Stanford University

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