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Solving Our Problem With Math

A rigid focus on the 'right answer' is needlessly turning students off from a field that's all about asking interesting questions

By Eugenia Cheng

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Periodically during tax season a meme goes around saying something like this: *I sure am glad we studied triangles every time triangle season comes around*. The implication here is that we never need triangles in real life, whereas we do need to understand taxes, and so it would have been much more useful to study taxes in school rather than all that pointless stuff about triangles.

This meme makes me sad in many different ways at once. It does have an element of truth in it: Many things we do in math at school will never be directly useful in daily life.

One way we could remedy that would be to teach math that is directly useful instead. I suppose this would mean things like taxes, mortgages, inflation, debt repayment, budgeting. Personally, I think that sounds awfully boring. It's also limiting: If you teach "How to Do Taxes," then it's not really applicable to anything except doing your taxes.

Another way is to do a better job of conveying the real usefulness of math, which is about exploration, logic and imagination.

There was another meme that went around during the COVID-19 pandemic, depicting a math teacher teaching a class about exponentials, and some bored students saying "When are we ever going to need this in life?" Unfortunately, when the pandemic began it would have been helpful if more people had understood exponentials. Instead, when scientists tried to point out, using exponentials, that it looked like things were going to get bad, far too many people thought the scientists were scaremongering or making things up.

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Some people like math because they think it has clear right-and-wrong answers. They find it easy to get the answers, and this makes them feel smart. Some people dislike or even fear it for more or less the same reason, but the other way around: it has clear right-and-wrong answers, but they find it hard to get the answers, and they may well have been made to feel stupid.

However, this image of a rigid world with clear answers is a very limited view of what math is. Thanks to this image, too many people are being put off math unnecessarily; they've only been shown some very narrow, unimaginative version of it, a version that doesn't allow for any personal input and curiosity of their own.

I would like to show math in a different emotional light. I want to encourage and validate the asking of questions, the ones children may want to ask but which math class doesn't seem to answer, the ones that made people say you should just buckle down and do your homework. The ones that make some people feel they are not a "math person," because the people who did well in tests didn't seem to be asking those questions. Questions like: Why does 1+1=2? Why can't we divide by 0? Where does math come from? How do we know it is right? These questions are not usually on the curriculum.

The rigidity of the curriculum and the exam system put me off math in elementary school too. I quite liked math when I was 5 years old. But my interest suffered a continuous deterioration through elementary school, and then I reached a point in middle school when I actively disliked math lessons as I found them tedious and pedantic. One problem for many children is the prominence of times tables. It can seem like memorizing times tables is a key part of being a good mathematician. This is not the case at all. I have personally never memorized my times tables. (I have learned how times tables work, and can do them relatively quickly—but only up to 11.) My wonderful Ph.D. supervisor, Martin Hyland, tells a story of his own childhood run-ins with times tables: When he was 8, his class was tested on times tables every day, and any child who got everything right three days in a row could stop doing the tests. He was the only child in the class who never achieved that. He was also the only one who became a world-renowned research mathematician. As he puts it, he has a "poor memory for what seems meaningless" but a "good memory for the shape of ideas."

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In school math, we put too much emphasis on answering questions rather than on asking them. It might seem that math is about answering questions, but one of the most important parts of math is the posing of questions. Those questions might sometimes appear vague, naive or confused, but they can lead to some of the most profound mathematics that's out there. These questions align with qualities we often don't associate with math: creativity, rule-breaking, play. We should encourage, not suppress them. If we give students the impression that they shouldn't ask those questions, we're telling them that math is rigid and autocratic. And that is the opposite of what math is.

Take "1+1=2," for example. This might seem like an obvious mathematical truth, but there are contexts in which different outcomes occur. If you mix one color of paint with one other color of paint you get one new color, not two. If you turn a piece of paper over once and then turn it over one more time you get back to where you started. These are valid outcomes that are also studied by mathematicians; questioning the equation 1+1=2 leads us to deeper mathematics.

For me, the education situation improved in college-level math, which tends to shift the focus from answers to justifications. This can be a shock to those who previously liked math because they found it easy to get the right answers. In college the questions are likely to move away from "What is the answer to this question?" toward "Show that this is the correct answer." The "answer" is actually given in the question, so that there is no emphasis on what the answer is, only the justification.

We could shift the emphasis in this way for children as well. Instead of asking "What is 6 × 8?" we could ask them "Show that 6 × 8 = 48." I can intone "six eights make 48" without engaging any part of my conscious brain. But what matters is that if someone questioned it, I could provide several different explanations to back up my answer.

Having different ways to think about something constitutes a deeper understanding of that thing, and it gives more ways to check that what you're doing is secure. It's a bit like if you're building some scaffolding to climb up to the roof of your house. Before putting your life at risk, you might want to check that the scaffolding is secure in various ways, not just one. This is why it's important to see that math isn't just about getting the right answer, but about how you know it's the right answer. Having a good way to tell that something is right is much more broadly applicable than knowing the answer to specific questions, and thus more useful.

This is really the point of logical rigor and abstract math. It enables us to package up ideas and treat them as building blocks so that we can understand increasingly complicated concepts. Then, by continuing to question and explore, we can create things that are further and further from those basic building blocks—like starting with the idea of exponential growth and ending up with an understanding of how viruses spread.

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