Could small tweaks reap big rewards in math education?

By Kevin Hartnett

Math education in the United States is a subject of constant anxiety. Our country’s future feels imperiled when our students land in the middle of the pack on international standardized tests, behind many Asian countries, most of Western Europe, and the likes of Slovenia and Latvia. There’s also personal angst, each time a kid throws down his pencil and concludes he’s just not meant for arithmetic.

A wholesale revision of the way we teach math is a tempting idea, either in the form of a fully rebooted curriculum or in dramatic changes to teacher training. This explains some of the recent popularity in the United States of Singapore math, for instance. But maybe there’s another way.

Over the last decade, researchers in cognitive psychology have found that better math education comes from surprisingly simple changes in the way numerical concepts are presented. These insights have the potential to shake up the way math is taught in the classroom, and even move the country up in those international rankings.

Consider something as elementary as patterns. In a paper published in the most recent issue of Child Development, Nicole McNeil of the University of Notre Dame and Emily Fyfe, a graduate student at Vanderbilt University, ran an experiment in which preschool-age children were taught patterns using one of two methods.

In the first method, the researchers told kids to think of patterns in concrete terms, as in “red block, blue block, red block, blue block.” In the second, they taught students to describe the same pattern with abstract labels, “a, b, a, b.” McNeil and Fyfe found that students who learned with abstract labels had an easier time seeing the general rules behind what they were learning. They were also better able to transfer the skills to other patterning problems, suggesting that teaching a concept correctly upfront improves math achievement down the line. “Some relatively small changes that we may not think about can cascade to have bigger effects on the way children think about different math concepts,” McNeil says.

Adjusting traditional English syntax also offers interesting possibilities. In 2003, cognitive psychologists at Indiana University found that elementary school students understand fractions better when, for example, ¼ is described as “of four parts, one,” which is how fractions are spoken of in South Korea, rather than as “one-fourth.” Another study found that students grasp the concept of cardinality — the total number of objects in a set — more effectively when the teacher names the objects first, as in “cars, there are three,” rather than, “there are three cars.” The reason is that when “cars” is the last thing small children hear, they fixate on the objects themselves at the expense of what they’re supposed to be learning.

In previous research, McNeil had found that similarly small adjustments in the way students are introduced to the equal sign can make a difference later on. When students in the United States learn about equations, it’s usually with an operation on the left side of the equal sign and a blank on the right (12+7=\_\_). This leads kids to misconstrue the equal sign as meaning something like “fill in the blank,” rather than as a symbol that indicates equality between two sides. The misconception causes problems years later when students learn algebra and need to start performing operations on both sides of the equal sign. McNeil found that a simple way to solve this is to vary the placement of the blank, so that in some problems children fill in the answer on the left side and in others they fill it in on the right.

The idea that an understanding of children’s thinking should influence the way math is taught is not new. Informally, classroom teachers are always making on-the-fly adjustments in search of an approach that makes a concept click with pupils. Researchers have also been doing this kind of work for a long time, though the application of cognitive psychology to math instruction intensified with the creation of the Institute for Education Sciences in 2002. The organization operates out of the Department of Education and was created in conjunction with the No Child Left Behind Act. It funds research that attempts to determine which teaching practices work best, and it has placed a particular emphasis on funding cognitive experiments.

The institute “attracted a lot of psychologists by making this money available. I think it’s a success story,” says Bethany Rittle-Johnson, a psychologist at Vanderbilt University who studies math pedagogy.

As a tool for improving math teaching, cognitive psychology has a lot of appeal. Math concepts are deep and subtle, and build on each other, such that slight misunderstandings early on can cause bigger problems later when students need to use basic ideas to learn more complicated material. Give that, it makes sense that we’d want to figure out just the right way to present concepts to a young child’s brain.

Some researchers worry, though, that while small adjustments can generate encouraging results in lab experiments, they’re not enough to alter the trajectory of a child’s math education or to fix a system of math education widely seen as in need of major improvement. Drew Bailey, a psychologist at the University of California Irvine School of Education, has written about what he calls “fade out,” or the tendency of math interventions to generate temporary bumps in achievement, which disappear over time. Rittle-Johnson is also skeptical that small adjustments in preschool and elementary school math instruction are enough to produce significant downstream benefits.

“This idea that it’s an inoculation, that if we fix the problems early we won’t have problems later, we were hoping it was going to be true and some people like to think it’s true, but I don’t know a single piece of evidence that bears that out,” she says.

Yet despite these concerns, Rittle-Johnson and others continue to look to cognitive psychology as an answer to the country’s math education woes. This is partly because other avenues for reform are so hard to implement. Reworking the way American math teachers are trained is a generational problem, and broad curricular changes often look good coming off the presses, but end up proving hard to implement. By comparison, asking teachers to adjust the way they describe fractions or to tweak the way they present addition problems, is something that could start happening tomorrow.

“The hope is that you teach this a little better, teach that a little better, we reach enough teachers, and you get some sustained [improvement],” says Rittle-Johnson. Indeed, it’s these little additions to the field that hopefully will generate exponential learning results, which can compound over time.