Ask A Scientist: What Should Preschool Math Look Like?

This is the first in a two-part series.

The debate over what early math should look like and what should be included in the Common Core State Standards for math is one of the most contentious in education circles. Bethany Rittle-Johnson is a professor of psychology and human development at Vanderbilt University in Tennessee who studies early math and specifically the importance of teaching young children about patterns. Patterns were mostly left out of the common core math standards in the early grades (kindergarten and 1st grade) due to a lack of evidence that they helped children understand later math concepts. Rittle-Johnson’s research on what children take away form learning repeating patterns, however, along with the research of several others that has come out since the standards were written, suggest that patterns should be added back in.

We spoke with Rittle-Johnson at length about both her work with patterns and the more wide-ranging question of what math should look like for preschool students. Should students use objects, called manipulatives, to practice addition? At what point should they begin to learn symbols? Is counting important? How do students figure out math rules?

Our conversation was so engaging, that it will be published on Early Years in two parts. The first part, edited for length and clarity below, is on best practices for early math.

Can you give an overview of what you research and explain why it’s interesting to you?

I study how children learn math. I find that mathematics is a great topic to study with children’s learning because it tells us a lot about how kids think and it has implications for how we can help them learn the important school subjects.

There’s a debate raging right now, a debate that has been raging for many years probably, about whether it’s best to memorize math facts in early childhood or whether it’s best to learn about the concepts undergirding mathematics. Which camp do you fall into?

Actually, I think it’s a silly argument because the evidence is pretty clear that children really need to do both things. Understanding is super-important, but understanding relies on knowing enough that you can understand it. If you have to spend all your time figuring out what two plus three is, then you can’t notice relationships between number pairs, [for example].

What we really need to do, and what I’ve done all my career, is think about how we can help kids learn facts and strategies as well as understanding how those two things actually support each other instead of work against each other.

Can you give me an example of a way that those two things might work together, say, when solving a math problem in 1st grade?

It’s really important that you figure out that you can add [numbers] in either order and it’s going to get you the same answer. When you figure that out, you understand something important about addition and you have half as many things to remember.

It’s not very effective to just tell kids that, though. They have to have experiences with it. So if kids can start noticing these patterns like, “Oh boy, when I add two plus three, I get five, and when I add three plus two, I get five.” Those kinds of experiences can help them understand this idea that the order you add in doesn’t make a difference.

But if I’m spending all of my time going 1, 2, 3 . . . 1, 2 . . . 1, 2, 3, 4, 5 to figure out that three plus two is five, then that takes up all my resources, so I don’t have time to sit back and realize these relationships. And then also recognize that it’s not true for subtraction. Because some kids decide the order doesn’t matter for addition so it must not matter for subtraction and of course it matters a great deal for subtraction.

We can’t just hope that kids notice these [math rules], so how we structure problems matters. [For example,] you want to put three plus two and two plus three next to each other [on a worksheet]. If the problems are randomly distributed, that’s not going to help as much as if they’re together.

Very interesting. Can you give me another example?

A colleague of mine, Nicole McNeil, [a psychology professor at the University of Notre Dame], has done really nice work on how the way we have children practice arithmetic facts can help them understand the equal sign and get some basic knowledge that’s foundational to algebraic thinking.
As the kids are practicing solving these problems they're learning their arithmetic facts, and they learn them just as well. [But instead of doing all the addition problems for adding two.] they might work on all the problems that add up to six.

So instead of two plus two is four, two plus three is five, two plus four is six, they're going to focus on getting six? To get to six, two plus four or three plus three or five plus one?

Perfect. It's about the results.

And another thing—kids actually make this very smart inference that just happens to not work very well long-term, which is that the equals sign means: "Add up the numbers."

We've read those textbooks, Nicole [McNeil] and I and others, and 97 percent of the problems [students] see have the equal sign at the end when they're in 1st, 2nd, and 3rd grade. So they think oh, it just means. "Get the answer." And we have really clear evidence that that messes up when they get to algebra, where you need to understand the equal sign means each side is the same as the other side. And we see a lot of middle school kids who still don't really understand the equal sign.

There's some nice evidence by Nicole McNeil and Eric Knuth, [an education professor at the University of Wisconsin, Madison], and others that kids in middle school are still struggling with the equal sign. They sort of get it, but not really, so they really struggle in [algebraic] equation-solving.

That makes complete sense, but I wouldn't have thought it through.

The nice thing that Nicole [McNeil] has been showing in her work with 2nd graders is that the kids learn the arithmetic facts just as well [when problems are arranged by sums, not addends] but they understand the equal sign a lot better. [Note: That is, instead of seeing a series like 1+6, 2+6, 3+6, etc., students would see 1+5, 2+4, 3+3, etc., because in the latter set, each problem adds up to six.] Practice can support understanding, but we don't get that for free. If we can set up practice in smart ways, then we can really help kids understand better.

How important do you think it is for kids in preschool through 1st grade to do this kind of practice with physical manipulatives as opposed to practicing with problems written out on paper?

That's been an interesting debate, too. I don't think I'm 100 percent sure of the answer on this, and it's actually not work I do myself. But Nicole McNeil and some others do work on this. My sense is that there are advantages to [working with] concrete manipulatives, but there are a lot of advantages to not [working with] them, too. There's this idea called "concreteness fading," which is that you start with [hands-on manipulatives] but then you fade them away until you switch to just the symbols.

I did this work with patterns with these cute plastic bugs, and sometimes the kids just wanted to play with the bugs. Manipulatives can distract kids or they can get them to pay attention to things like color when it's irrelevant. So we do need to help bridge kids to abstract symbols. Kids actually can learn a decent amount from abstract symbols.

I think there are some parents out there who would hear about this and say, "Oh, it's more advanced at an earlier age. We've got a ton of 5-year-olds doing pencil-on-paper math computation, and that's terrible." What do you think about that?

I mean I've got to tell you, I'm hearing about kids doing worksheets as 3- and 4-year-olds. And I have not done research on this, but it strikes me as a terrible idea. I think this concern, which is very legitimate, that if kids are just dealing with abstract symbols and they're just a bunch of gobbleygook to them or just a bunch of memorized things—that's going to cause some pretty big problems and also maybe make them start to hate math at a younger age. Little kids don't hate math.

That's why this concreteness fading is a nice way to think about how we're going to be having these concrete, physical things to ground it and give it meaning. But we're going to push away from that.

I'm trying to think if that research of pushing away to abstract has been done before kids are 5. And I actually don't know if it has been.

So what should math look like for a preschooler?

The idea that there's real mathematics in the world that 3- and 4-year-olds can be thinking about is an important message. And there are some nice curriculums out there for preschool math, and you might hear the word curriculum and think, "Oh my God." But, you know, they're preschool curriculums. They're not 2nd grade curriculums that were just dumbed down or something. So they involve a lot of activities and sense-making. Some of them have nice computer software where kids are engaging with virtual things. So they're getting kids to be thinking about and making sense of what they're doing.

So number and numeracy is super-important, and that's what's getting a lot of attention.
Numeracy means knowing that if there's two dolls on the ground, that's two dolls and not three dolls? Is that what you mean by numeracy?

Yeah, I do. I think that a lot of people would find it surprising that when children count objects, they don’t know that that last number that they say indicates how many there are. I mean, children do memorize [numbers]. We really support kids memorizing the count sequence and counting, pointing to objects and counting them. And if they count and I say, "Okay, how many are there?" They just count over and over again. They don’t actually know: "Because I just counted to four, there are four objects." If you say, "Can you give me four?" they give you a random handful. Then when you say, "Oh, that's not quite four," they just randomly give you more.

So you really need to understand what four is. You need to understand four objects, the verbal number named four, then eventually the written symbol four. And that’s important, and it doesn't come for free. Just because your child can count objects and recite the count word sequence, as we call it, that actually doesn't mean those words have any meaning to them. And so that’s really important. That’s the big push.

Middle-class children get a fair amount of support for that knowledge, and that’s certainly something that we see that children from less-advantaged backgrounds can need extra support because they're not counting 50 times a week and kind of figuring it out. Numbers and the names and the symbols and the quantities that go together, oftentimes we call that numeracy. Then eventually learning that six is more than four, so the relative size of numbers is a really important idea that kids really need to get. And I think it gets a lot of attention these days, and I think it deserves a lot of attention. But I have to say that math is more than numbers.

Which brings us into your research on patterns, right?

Yes, that’s why I've been looking at this research on kids thinking about repeating patterns.

To be continued...

Photo: Bethany Rittle-Johnson, courtesy Vanderbilt University

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