Why Word Problems Are Such a Struggle for Students—And What Teachers Can Do

By Sarah Schwartz — May 01, 2023 12 min read

Give Cindy Cliche a math word problem, and she can tell you exactly where most students are going to trip up.

Cliche, the district math coordinator in the Murfreesboro City school district in Tennessee, has spent decades teaching elementary schoolers how to tackle their first word problems and now coaches teachers in how to do the same. Kids' struggles, for the most part, haven't changed, she said.

Take this problem, which students might work on in 1st grade: There are some bunnies on the grass. Three bunnies hop over, and then there are five total. How many bunnies were there to begin with?

The problem is asking about a change: What's the starting, unknown quantity of bunnies, if adding 3 to that quantity equals 5? In other words, $x + 3 = 5$. But most 1st graders don't make that connection right away, Cliche said. Instead, they see the numbers 3 and 5, and they add them.

"Nine times out of 10 they're going to say, 'eight,'" Cliche said. "They're number pluckers. They take this number and this number and they add them together or they take them apart."

This is one of the biggest challenges in word problem-solving, educators and researchers agree—getting students to understand that the written story on the page represents a math story, and that the math story can be translated into an equation.

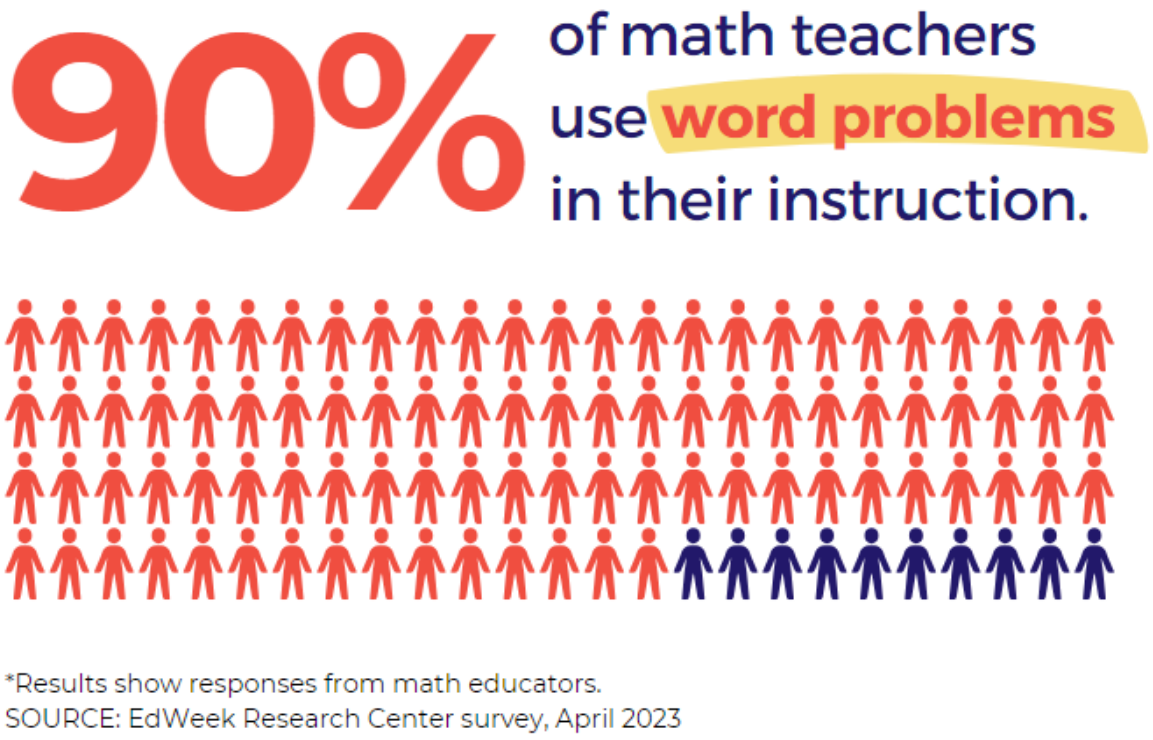
Making this connection is a key part of early mathematical sense-making. It helps students begin to understand that math isn't just about numbers on a page, but a way of representing relationships in the world. And it's one of the ways that kids learn to unite conceptual understanding of problems with the procedures they will need to solve them.

"When students struggle [with word problems], it tends to be everything else they have to do to get to the calculation," said Brian Bushart, a 4th grade teacher in the West Irondequoit schools in Rochester, N.Y.

There are evidence-backed strategies that teachers can use to help students make these connections, researchers say.

These approaches teach students how to understand "math language," how to devise a plan of attack for a problem, and how to recognize different problem types. And though they provide students tools and explicit strategies, these techniques are designed to support kids' sense-making, not circumvent it, said Lynn Fuchs, a research professor in the department of special education at Vanderbilt University.

The goal, she said, is "understanding the full narrative of what's being presented."



How word problems are used in early grades

Story problems serve a few different purposes in early grades, said Nicole McNeil, a professor of psychology at the University of Notre Dame who studies students' cognitive development in math.

They can help connect children's preexisting knowledge to the math they're learning in class—"activating that knowledge kids have in their everyday life, and then showing, how do mathematicians represent that?" McNeil said.

Cliche likes to use word problems in this way to introduce the concept of dividing by fractions.

“We’ll tell the kids, ‘I have three sandwiches here and I need to divide them in half so that everyone will get a piece,’” she said. “‘How many people can I feed?’”

After students solve the problem, Cliche introduces the operation that students could use to divide by fractions—marrying this conceptual understanding with the procedure that students would use going forward.

But word problems can also be used in the opposite direction, to see if students can apply their understanding of equations they’ve learned to real-world situations, McNeil said.

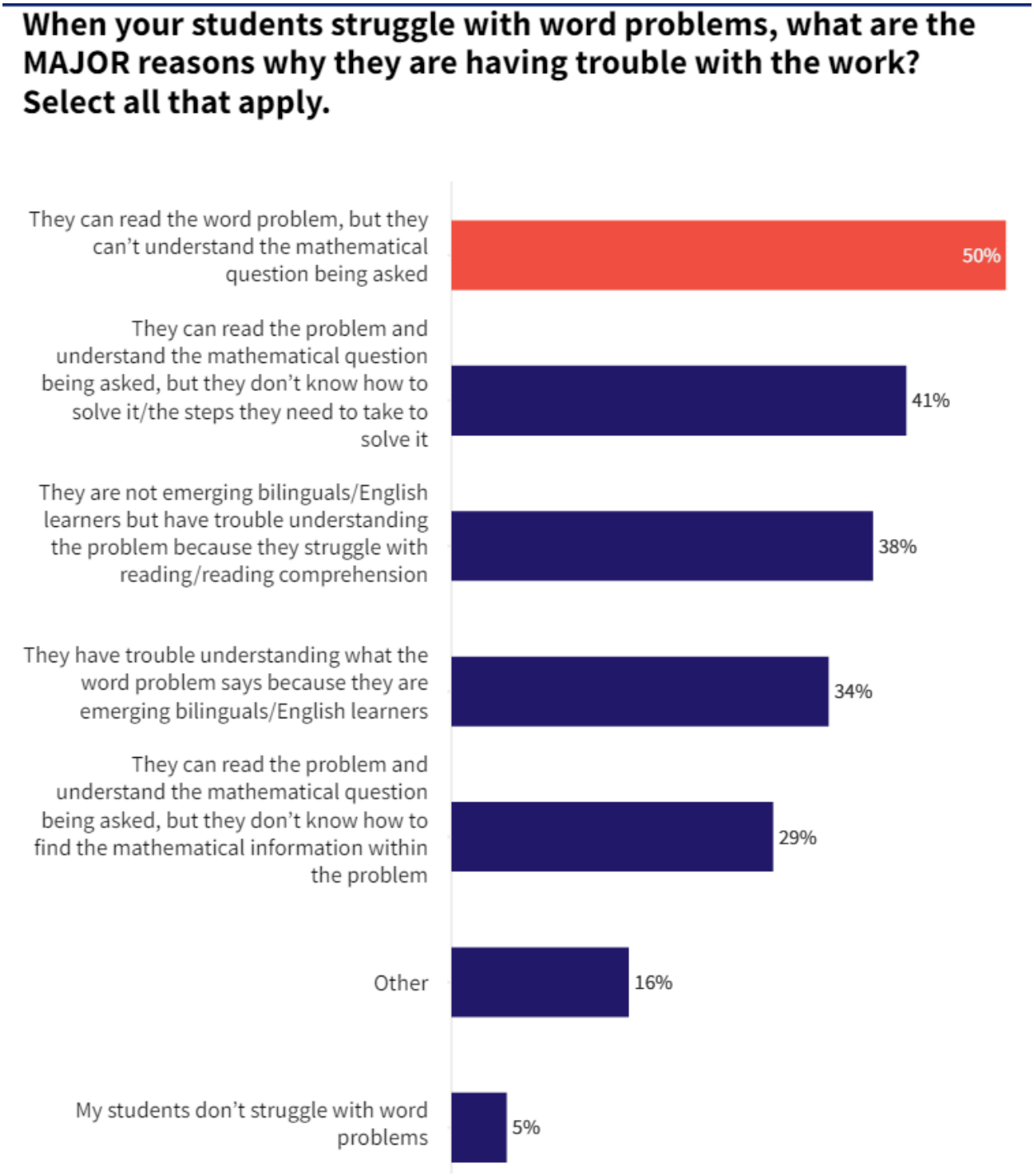
And there’s another, practical reason that teachers practice word problems: They’re ubiquitous in curriculum and they’re frequently tested.

There are lots of different kinds of problems that kids could work on in math classes, said Tamisha Thompson, a STEAM (for science, technology, engineering, the arts, and math) instructional coach in the Millbury public schools in Massachusetts, and a doctoral student in learning sciences at Worcester Polytechnic Institute.

Many story problems have one right answer, but there are also problems that could have multiple answers—or ones that aren’t solvable. Spending more time with a broader diversity of problems could encourage more creative mathematical thinking, Thompson said. “But we’re really driven by standardized tests,” she said. “And standardized tests typically have one right answer.”

In general, between 30 percent and 50 percent of standardized-test items in math feature these kinds of story problems, said Sarah Powell, an associate professor in the department of special education at the University of Texas at Austin.

“Until things change, and until we write better and different tests, if you want students to show their math knowledge, they have to show that through word problem-solving,” Powell said.



Why students struggle with word problems

Sometimes, students struggle with word problems because they don't know where to start. Just reading the problem can be the first hurdle. If early-elementary schoolers don't have the reading skills to decode the words, or if they don't know some of the vocabulary, they'll struggle, said McNeil.

That can result in students scoring low on these portions of standardized tests, even if they understand the underlying math concepts—something McNeil considers to be a design flaw. “You’re trying to assess math, not reading twice,” she said.

Then, there’s math-specific vocabulary. What do words like “fewer than,” or “the rest,” mean in math language, and how do they prompt different actions depending on their placement in a problem?

Even if students can read the problem, they may struggle to figure out what it’s asking them to do, said Powell. They need to identify relevant information and ignore irrelevant information—including data that may be presented in charts or graphs. Then, they have to choose an operation to use to solve the problem.

Only once students have gone through all these steps do they actually perform a calculation. Teaching kids how to work through all these setup steps takes time. But it’s time that a lot of schools don’t take, said Cliche, who has also worked previously as a state math trainer for Tennessee. Word problems aren’t often the focus of instruction—rather, they’re seen as a final exercise in transfer after a lot of practice with algorithms, she said.

A second problem: Many schools teach shortcut strategies for deciphering word problems that aren’t effective, Powell said.

Word problem “key words” charts abound on lesson-sharing sites like Teachers Pay Teachers. These graphic organizers are designed to remind students which math words signal different operations. When you see the word “more,” for example, that means add the numbers in the problem.

Talking with students about the meaning of math vocabulary is useful, said Powell. But using specific words as cues to add or subtract is a flawed strategy, Powell said, because “there is no single word that means an operation.” The word “more” might mean that the numbers need to be added together—or it might mean something else in context. Some problems have no key words at all.

In a 2022 paper, Powell and her colleagues analyzed more than 200 word problems from Partnership for Assessment of Readiness for College and Careers (PARCC) and Smarter Balanced math tests in elementary and middle school grades. Those tests are given by states for federal accountability purposes.

They found that using the key words strategy would lead students to choose the right operation to solve the problem less than half the time for single-step problems and less than 10 percent of the time for multistep problems.

Evidence-based strategies for helping struggling students

So if key words aren’t an effective strategy to support students who struggle, what is?

One evidence-based approach is called schema-based instruction. This approach categorizes problems into different types, depending on the math event portrayed, said Fuchs, who has studied schema-based instruction for more than two decades.

But unlike key words, schemas don't tell students what operations to use. Instead, they help students form a mental model of a math event. They still need to read the problem, understand how that story maps onto their mental model, and figure out what information is missing, Fuchs said.

One type of schema, for example, is a "total" or "combine" problem, in which two quantities together make a total: "Jose has five apples. Carlos has two apples. How many apples do they have together?" In this case, students would need to add to get the answer.

But this is also a total problem: "Together, Jose and Carlos have seven apples. If Jose has five apples, how many apples does Carlos have?"

Here, adding the two numbers in the problem would bring students to the wrong answer. They need to understand that seven is the total, five is one part of the total, and there is another, unknown part—and then solve from there.

To introduce schemas, Vanderbilt's Fuchs said, "we start with a child and the teacher representing the mathematical event in a concrete way."

Take a "difference" problem, which compares a larger quantity and a smaller quantity for a difference. To demonstrate this, an early-elementary teacher might show the difference in height between two students or the difference in length of two posters in the room.

Eventually, the teacher would introduce other ways of representing this "difference" event, like drawing one smaller and one larger rectangle on a piece of paper. Then, Fuchs said, the teacher would explain the "difference" event with a number sentence—the formula for calculating difference—to connect the conceptual understanding with the procedure. Students would then learn a solution strategy for the schema.

Children can then use their understanding of these different problem types to solve new problems, Fuchs said.

There are other strategies for word-problem-solving, too.

- Attack strategies. Several studies have found that giving students a consistent set of steps they can use to approach every problem has positive effects. These attack strategies are different from schemas because they can be used with any problem type, offering more general guidance like reminders to read the problem and pull out relevant information.
- Embedded vocabulary. A 2021 study from Fuchs and her colleagues found that math-specific vocabulary instruction helped students get better at word problem-solving. These vocabulary lessons were embedded into schema instruction, and they focused on words that had a specific meaning in a math context—teaching kids the difference between "more than" and "then there were more," for example.
- 'Numberless' problems. Some educators have also developed their own strategies. One of these is what's called "numberless" word problems. A numberless problem has the same structure as a regular story problem but with the quantities strategically removed. An initial

statement might say, for example, “Kevin found some bird feathers in the park. On his way home, he lost some of the feathers.”

With numberless problems, instead of jumping to the calculation, “the conversation is the goal,” said Bushart, the 4th grade teacher from New York, who has created a website bank of numberless problems that teachers can use.

The teacher talks with students about the change the story shows and what numbers might be reasonable—and not reasonable. The process is a form of scaffolding, Bushart said: a way to get students thinking conceptually about problems from the start.

Balancing structure and challenge

These approaches all rely on explicit teaching to give students tools that can help them succeed with problems they’re likely to see often in class or on tests.

But many math educators also use word problems that move beyond these common structures, in an attempt to engage students in creative problem-solving. Figuring out how much structure to provide—and how much challenge—can be a delicate balance.

These kinds of problems often require that students integrate real-life knowledge, and challenge them to “think beyond straightforward applications of mathematical situations,” said McNeil of Notre Dame.

There may be an extra number in the problem that kids don’t have to use. Or the problem might pose a question that would lead students to a nonsensical answer if they just used their procedural knowledge. For example: 65 students are going on a field trip. If each bus can hold 10 students, how many buses are needed?

Students might do the calculation and answer this question with 6.5, but that number doesn’t make sense, said McNeil—you can’t have half a bus.

In a 2021 study, McNeil and her colleague Patrick Kirkland rewrote some of these challenging questions in a way that encouraged students to think more deeply about the problems. They found that middle school students who worked on these experimental problems were more likely than their peers to engage in deep mathematical thinking. But, they were also less likely to get the problems correct than their peers who did standard word problems.

Other research, with young children, has found that teaching students how to transfer their knowledge can help them work through novel problems.

When students are given only problems that are all structured the same way, even minor changes to that format can prevent them from recognizing problem schemas, said Fuchs.

“What we found in our line of work is that if you change the way the word problem reads, in only very minor ways, they no longer recognize that, this is a ‘change’ problem, or a ‘difference’ problem,” she said, referencing different problem schemas.

In the early 2000s, she and her colleagues tested interventions to help students transfer their knowledge to more complex, at times open-ended problems. They found that when children were taught about the notion of transfer, shown examples of different forms of the same problem type, and encouraged to find examples in their own lives, they performed better on novel, multistep problems than their peers who had only received schema instruction.

The results are an example of how explicit instruction can lay the groundwork for students to be successful with more open-ended problem-solving, Fuchs said.

Exactly how to sequence this learning—when to lean into structure and when to release students into challenge—is an open question, McNeil said.

“We need more researchers focused on what are the best structures? What order should things go in? What is the appropriate scope and sequence for word problems?” she said. “We don’t have that information yet.”