Why Memorizing Key Words Is Insufficient in Mathematical Word Problem Solving

A research-informed perspective on word problem instruction

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> ***"Teaching students to recognize the structure of a word problem—not hunt for key words—is one of the most well-supported findings in mathematics education research."***

Introduction

When students struggle with mathematical word problems, teachers often reach for a familiar solution: teach them to look for key words. Circle *altogether* — add. See *left over* — subtract. Spot *each* — multiply. This approach is intuitive, easy to teach, and unfortunately, one of the most consistently discredited strategies in mathematics education research.

The problem is not that mathematical language is unimportant. It is. The problem is that words do not carry fixed operational meaning. They carry contextual meaning. A student who has been trained to treat *more* as a signal to add will fail the moment a problem uses *more* in a comparison context. That failure is not a gap in arithmetic ability — it is a predictable consequence of a strategy that was never built to generalize.

This article draws on a substantial body of peer-reviewed research to explain why key word instruction falls short, what it fails to teach, and what teachers should do instead. The evidence points clearly toward schema-based instruction — an approach that teaches students to recognize the mathematical structure of a problem before attempting to solve it.

The Context Problem: Why Words Cannot Be Trusted in Isolation

Natural language is not a fixed code. The same word can signal entirely different mathematical operations depending on the context in which it appears. This is not an edge case — it is a fundamental property of language that makes key word strategies structurally unreliable.

Consider the word *increase*. In the problem "If you increase the number of apples by 5, how many apples do you have?" the word signals addition. In "If the population of a town increases by 20% each year, what will the population be in 5 years?" the same word signals multiplicative reasoning. The word has not changed. The context has — and the context is everything.

The word *per* presents a similar challenge. “If you drive 60 miles in 2 hours, what is your speed per hour?” requires division. “If apples cost $2 per pound, how much will 5 pounds cost?” requires multiplication. The words *more*, *less*, *total*, and *each* all behave the same way: their operational meaning is determined not by the word itself, but by the mathematical relationship the problem describes.

Researchers Boonen, Van der Schoot, Van Wesel, De Vries, and Jolles (2013) documented this problem directly, finding that students who relied on surface-level linguistic cues — including key words — performed significantly worse on non-standard problem structures than students who had developed deeper comprehension strategies. The key word approach, they concluded, teaches students to react to surface features rather than understand mathematical relationships.

Boonen, A. J. H., Van der Schoot, M., Van Wesel, F., De Vries, M. H., & Jolles, J. (2013). What underlies successful word problem solving? A path analysis in sixth grade students. Contemporary Educational Psychology, 38(3), 271–279.

What the Research Says: Key Words Do Not Generalize

The limitations of key word instruction are not a new discovery. Powell and Fuchs (2010) noted that key word strategies “often lead students astray” because they fail on problems with inconsistent language — problems where the surface language does not align with the underlying operation. These are not trick questions. They are standard word problems that appear routinely in elementary and middle school mathematics.

A particularly well-documented failure point is the *compare* problem type. Problems such as “Julia has 8 marbles. She has 3 more than Marcus. How many does Marcus have?” contain the word *more* but require subtraction. Students trained on key words will add. This error pattern is so consistent that researchers use it as a diagnostic marker for key word dependency (Lewis & Mayer, 1987).

Lewis, A. B., & Mayer, R. E. (1987). Students’ miscomprehension of relational statements in arithmetic word problems. Journal of Educational Psychology, 79(4), 363–371.

Powell, S. R., & Fuchs, L. S. (2010). Contribution of equal-sign instruction beyond word-problem tutoring for third-grade students with mathematics difficulty. Journal of Educational Psychology, 102(2), 381–394.

The Institute of Education Sciences (IES) Practice Guide on *Assisting Students Struggling with Mathematics* explicitly recommends against key word strategies, advising instead that teachers help students identify the underlying structure of word problems — the mathematical relationship between quantities — rather than surface-level linguistic features (Gersten et al., 2009).

Gersten, R., Beckmann, S., Clarke, B., Foegen, A., Marsh, L., Star, J. R., & Witzel, B. (2009). Assisting students struggling with mathematics: Response to Intervention (RtI) for elementary and middle grades (NCEE 2009-4060). National Center for Education Evaluation and Regional Assistance, IES.

The Alternative: Schema-Based Instruction

If key word instruction teaches students to react to surface features, schema-based instruction teaches them to understand mathematical structure. A schema is a framework for recognizing the type of relationship a problem describes. For additive word problems, three schemas account for every problem type a student will encounter from grades 1 through 5: Part-Part-Total, Change, and Compare.

The research base for schema-based instruction is extensive and consistent. Jitendra and colleagues have conducted multiple studies demonstrating that students who receive schema-based instruction significantly outperform those who receive general strategy instruction — not just on immediate posttests, but on delayed assessments that measure whether learning holds over time (Jitendra et al., 2007; Jitendra & Hoff, 1996).

Jitendra, A. K., Griffin, C. C., Haria, P., Leh, J., Adams, A., & Kaduvettoor, A. (2007). A comparison of single and multiple strategy instruction on third-grade students' mathematical problem solving. Journal of Educational Psychology, 99(1), 115–127.

Jitendra, A. K., & Hoff, K. (1996). The effects of schema-based instruction on the mathematical word problem-solving performance of students with learning disabilities. Journal of Learning Disabilities, 29(5), 422–438.

Fuchs and colleagues extended this work to larger populations, showing that schema-based tutoring benefited not only students with learning disabilities but also students at risk for mathematics difficulty in general education settings. Effect sizes in these studies ranged from moderate to large, with delayed posttest effects as high as 0.69 (Fuchs et al., 2008).

Fuchs, L. S., Seethaler, P. M., Powell, S. R., Fuchs, D., Hamlett, C. L., & Fletcher, J. M. (2008). Effects of preventative tutoring on the mathematical problem solving of third-grade students with math and reading difficulties. Exceptional Children, 74(2), 155–173.

The IRIS Center at Vanderbilt University, one of the leading resources for evidence-based special education practice, identifies schema-based instruction as a well-validated approach to word problem instruction, noting that it "helps students identify the type of problem they are solving before they attempt to solve it" — a process that directly replaces the key word habit with something more durable and generalizable.

Why Structure Matters More Than Words

The central insight of schema-based instruction is that word problems are not primarily a language task — they are a relational reasoning task. The words describe a situation. The schema describes the mathematical relationship within that situation. Teaching students to identify the schema first means they are reading for meaning, not scanning for cues.

This distinction matters for all students, but it is especially important for students who struggle with reading. Research by Fuchs and colleagues (2004) found that word problem difficulty for low-performing students was driven less by computation and more by an inability to represent the problem structure. Key word instruction does nothing to address this. Schema instruction addresses it directly.

Fuchs, L. S., Fuchs, D., Prentice, K., Hamlett, C. L., Finelli, R., & Courey, S. J. (2004). Enhancing mathematical problem solving among third-grade students with schema-based instruction. Journal of Educational Psychology, 96(4), 635–647.

Graphic organizers — visual schema maps — play a key supporting role. Research from the Association for Middle Level Education found that when students use graphic organizers to represent word problem structure, they show improved ability to organize information, infer solutions, and communicate mathematical reasoning (Braselton & Decker, 1994). The schema map makes the structure visible and gives students a process they can apply consistently across problem types.

Braselton, S., & Decker, B. C. (1994). Using graphic organizers to improve the reading of mathematics. The Reading Teacher, 48(3), 276–281.

Conclusion

Key word instruction persists in classrooms not because it works, but because it feels like it should work. It is tidy, teachable, and produces short-term success on simple, well-formed problems. The trouble is that mathematics — and life — is full of problems that are not simple and well-formed. When students encounter those problems, key word training leaves them without a reliable strategy.

Schema-based instruction offers a genuine alternative. It is grounded in decades of peer-reviewed research, validated with diverse student populations, and recommended by the Institute of Education Sciences. Most importantly, it teaches students something that transfers — the ability to recognize what kind of problem they are solving before they attempt to solve it.

At Numeracy Consultants, the Word Problem Intervention Program is built entirely on this foundation. Every assessment, every lesson, and every resource is designed to develop schema recognition through explicit, intentional, direct instruction — because that is what the research supports, and because our students deserve instruction that actually works.

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