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Implementing Schema Instruction to Support Young Children With Word Problems: A Systematic Review

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Abstract

When young children are presented with mathematics word problems, they are asked to decode words, understand text, think critically, and perform calculations. Word problems are interdisciplinary and are known to be difficult for children across all grade levels. Schema instruction, in which children learn to solve word problems according to underlying concepts, has been identified as an evidence-based practice. Still, more attention needs to be devoted to how schema instruction impacts young children. We conducted a systematic search of experimental studies that implemented schema instruction with children in kindergarten, Grade 1, or Grade 2. In May of 2023, we conducted searches of three databases. To be included, studies had to be experimental (i.e., randomized-controlled trials, quasi-experiments, or single-case design) and peer reviewed or dissertations. Moreover, studies had to measure the impact of schema instruction on the word-problem performance of children in kindergarten, Grade 1, or Grade 2. Ultimately, we identified and included 13 studies with participants in Grades 1 and 2 (n ~ 2,100). Overall, schema instruction positively impacted word-problem outcomes. Common instructional components included: (a) systematic and explicit instruction on word-problem schemas; (b) diagrams, meta-equations, and gesturing; (c) the use of a problem-solving heuristic; (d) inclusion of numberless or intact story problems and isolated practice with identifying schemas; (e) explicit instruction on mathematics and word-problem specific vocabulary; (f) incorporating concrete or virtual manipulatives and a fact fluency component; and (g) the inclusion of a self-monitoring behavior component.

Keywords

schema instruction, word problems, intervention, elementary

Jordan practiced the cello for 35 minutes in the morning and 15 minutes in the afternoon. How long did Jordan practice the cello? To solve a routine mathematics word problem such as this, children must decode words, understand the text of the problem, create a plan for solving it, and perform calculations. Beginning in elementary school, children are exposed to a variety of word problems, including directive, routine, and non-routine word problems (Powell et al., 2022). Directive word problems instruct children to complete a specific mathematical task (e.g., *Find the product of 9 × 10*). Non-routine word problems are those that have more than one possible solution (e.g., *Tan has more money than Lee. Together, they have $30. How much money could Tan have?*). Routine word problems are set in a story context that children must interpret to find the single correct solution. This systematic review focused on routine word problems in kindergarten, Grade 1, and Grade 2. We refer to these grades as *the early grades.*

Word Problems in the Early Grades

Much of the existing word-problem intervention research focuses on children in Grades 3 through 12. However, based on the Common Core standards used in many states across the U.S., children are expected to solve word problems beginning in kindergarten (CCSSM; National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). Importantly, a number of studies have indicated that kindergarteners are capable of solving word problems (Carpenter et al., 1993; Croset et al., 2024; Elia, 2020). At this level, based on the CCSSM (2010), children solve word problems requiring addition and subtraction within 10. Children are taught to conceptualize addition scenarios as *putting together* and *adding to,* and subtraction scenarios as *taking apart* and *taking from.* As children learn to read in kindergarten, word problems may be orally presented.

In Grade 1, word problems increase in their computational demands and complexity (CCSSM, 2010). Grade 1 word problems require addition and subtraction within 20. Children must write corresponding equations, including a symbol for the unknown number, which can be in any position (e.g., 8 + ? = 11, 5 = ? − 3, 6 + 6 = ?). Additionally, word problems conceptualized as *putting together or adding to* can include three addends. Children learn of a third word-problem type, *comparing*, in Grade 1. Children build algebraic reasoning while solving these word problems (e.g., the communicative property and the inverse relation of addition and subtraction).

Subsequently, in Grade 2, children are expected to solve one- and two-step word problems involving addition and subtraction within 100 (CCSSM, 2010). Children continue to solve word problems conceptualized as *putting together* or *adding to, taking apart* or *taking from*, and *comparing*. However, at this level, children must also solve word problems involving length and money, as well as word problems with information presented in bar graphs (i.e., graphical displays of data). With the focus on word problems in the standards across kindergarten through Grade 2, it is crucial to understand how children in the early grades may experience difficulties with these tasks.

Word Problem Complexity

Many researchers have investigated the knowledge and skills required during word-problem solving. First, the linguistic and literacy demands of word problems are vast. Xu et al. (2022) determined that receptive vocabulary (i.e., children's ability to intake, process, and understand spoken vocabulary) predicted word-problem proficiency. Vilenius-Tuohimaa et al. (2008) examined the relation between reading skills and word-problem outcomes and determined that decoding skills and reading fluency influenced comprehension, and comprehension influenced word-problem outcomes. Moreover, a large body of research supports the critical relation between mathematics vocabulary knowledge and word-problem proficiency (e.g., Cartwright et al., 2022; Fuchs et al., 2015; Stevens et al., 2023).

Additionally, solving word problems involves computation. Children benefit from both a conceptual knowledge of operations and procedural fluency (Chan & Kwan, 2021; Pongsakdi et al., 2020). That is, along with having a conceptual understanding of addition as *putting together* or *adding to* and subtraction as *taking away* or *comparing*, children should have procedural fluency that supports efficient and accurate computation.

Beyond the knowledge and skills mentioned above, word-problem solving relies heavily on working memory and reasoning abilities (Passolunghi et al., 2022). Consider the word problem: *"Maelia is taking three classes. She has 17 pages to read for a class. So far, she has read 13 pages. How many more pages does Maelia need to read?"* To solve this word problem, children must focus on which value is missing (i.e., how many pages Maelia has left to read). Children must disregard the extraneous information that Maelia is taking three classes. Although this problem includes the word *more*, children must find the difference between the target number of pages and how many have been read. This process requires the child to disregard extraneous information and retain the critical information in their working memory until they determine the solution (i.e., the word problem's answer). Without engaging in reasoning, the child might focus on the word *more* and add 17 and 13.

Early childhood teachers face a unique challenge. At this stage, children must simultaneously learn how to decode words, understand text, add, and subtract. When solving word problems, children must implement multiple skills. Considering the complexity, range of difficulty, and numerous processes related to solving word problems, researchers must determine effective evidence-based practices for word problems in the early grades. In the next section, we describe one such evidence-based practice.

Schema Instruction

Schema instruction has been identified as an evidence-based practice for improving word-problem proficiency (Jitendra et al., 2015; Peltier et al., 2018; Root et al., 2021). Schema instruction is a method in which children learn to identify the underlying structure (i.e., concept) of various word-problem types and is grounded in cognitive load theory (Marshall, 1995; Sweller, 1994). In the early grades, children primarily solve additive word problems, meaning word problems that require addition or subtraction. Researchers have identified three reliable categories (i.e., schemas) for additive word problems, which we discuss in the next section (Nesher et al., 1982).

Schemas in the Early Grades

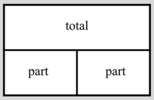
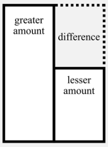
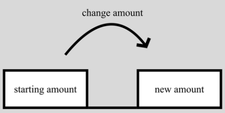
Commonly taught schemas in the early grades are *Total*, *Change*, and *Difference* (see Figure 1). In Total problems, parts are combined into a total. When the total amount is unknown, Total problems require addition, conceptualized as *putting together*. For example: *"The team scored 15 points in the first half and 8 points in the second half. How many points did they score in all?"* When one of the parts is unknown, Total problems are often solved using subtraction, conceptualized as *taking apart* (e.g., *The team scored 23 points. If they scored 15 points in the first half, how many did they score in the second half?*). Additionally, Total problems can have more than two parts. Across the literature, Total problems have also been referred to as *group*, *combine*, *put-together,* or *part-part-whole* problems (e.g., Bowman et al., 2020; Fuchs et al., 2014; Huang et al., 2012; Peltier & Vannest, 2018).

In Difference problems, a greater amount is compared with a lesser amount. In these problems, the *greater amount*, the *lesser amount*, or the *difference* can be unknown. For example: *"Nate read for 38 minutes on Thursday and 46 minutes on Friday. How much longer did he read on Friday?"* In this word problem, the *difference* is unknown. Consider this variation: *"Nate read for 38 minutes on Thursday. He read 8 minutes longer on Friday than he did on Thursday. How long did he read on Friday?"* In this variation, the *greater amount* is unknown. Difference problems have also been referred to as *compare* problems (e.g., Root et al., 2017).

In Change problems, a starting amount increases or decreases to a new amount. Thus, addition is conceptualized as *adding to,* and subtraction is conceptualized as *taking from.* These two variations have been called *change-get-more* and *change-get-less* (e.g., Chadli et al., 2018; Hughes & Cuevas, 2020). In Change problems, the *starting amount, change amount, or end amount* can be unknown. Consider the word problem: *"Jocelyn brought 24 cupcakes to school for her birthday. After passing out cupcakes to her classmates, she had 6 left over. How many cupcakes did Jocelyn pass out?"* In this word problem, the *change amount* is unknown. Moreover, Change problems can include more than one change (e.g., an increase followed by a decrease).

Figure 1

Examples of Total, Difference, and Change Problems With Unknowns in Each Position

Total *Parts are combined into a total.* 	**Missing addend or part unknown** *The family had 5 pets. They had 3 dogs, and the rest were cats. How many cats did the family have?*	**Missing total** *The family had 3 dogs and 2 cats. How many pets does the family have?*	-
Difference *A greater amount is compared with a lesser amount.* 	**Difference unknown** *The kindergarten cubbies are 12 inches tall, and the first-grade cubbies are 14 inches tall. How much taller are the first-grade cubbies than kindergarten cubbies?*	**Greater part unknown** *The kindergarten cubbies are 12 inches tall, and the first-grade cubbies are 2 inches taller. How tall are the first-grade cubbies?*	**Lesser part unknown** *The first-grade cubbies are 14 inches tall, and the kindergarten cubbies are 2 inches shorter. How tall are the kindergarten cubbies?*
Change *A starting amount increases or decreases to a new amount.* 	**Start unknown** *There were some pencils in the cup. The teacher put 10 more pencils in the cup. Now there are 13 pencils. How many pencils were in the cup to start?*	**Change unknown** *There were 13 books on the shelf. The librarian took some off. Now, there are 10 books on the shelf. How many books did the librarian take?*	**End result unknown** *There were 13 books on the shelf. The librarian took 3. How many books are on the shelf now?*

Schema Instruction in Practice

Although there is some variation in how schema instruction is applied across various studies, Powell (2011) outlined a foundational structure. First, schemas should be explicitly taught, and their accompanying strategies should be modeled. Typically, children should be given sufficient time to practice a schema before being introduced to another. Schema instruction teaches children to identify and differentiate between these problem types. After reading a word problem and determining the problem type, children can plan to solve it using the corresponding diagram or schema equation. Finally, children can identify and solve for the unknown.

Several terms have been used to describe schema instruction or specific variations of it: (a) schema-based instruction and schema-broadening instruction (Powell, 2011); (b) priming the problem structure or explicit instruction on identifying problem types (Jitendra et al., 2015); (c) modified schema-based instruction (Clausen et al., 2021); and (d) model-based problem solving (Myers et al., 2022; Xin, 2016). For the remainder of this systematic review, we will use the term *schema instruction* to describe any word-problem intervention in which children learn to identify word problems by their underlying schema (i.e., conceptual structure) and solve them accordingly.

Previous Syntheses, Meta-Analyses, and Reviews

Word-problem interventions have been the focus of reviews for over two decades (e.g., Jitendra & Xin, 1997). Many of these reviews have focused on a broad range of word-problem interventions (e.g., Kong et al., 2021; Lein et al., 2020; Zheng et al., 2013). To date, authors of at least half a dozen reviews focused exclusively on schema instruction (e.g., Clausen et al., 2021; Cook et al., 2020; Jitendra et al., 2015; Peltier & Vannest, 2017; Peltier et al., 2018; Powell, 2011). However, among these reviews, most included studies involved children in the late elementary grades and beyond. In this section, we summarize a selection of these reviews that, to an extent, included studies that focused on the word-problem outcomes of young children.

Peng et al. (2025) conducted a systematic review and network meta-analysis focused on group-design studies that implemented word-problem interventions with elementary children (Grades 1–5) with mathematics difficulty (MD). The authors analyzed and compared 53 studies to identify which combinations of instructional strategies were the most effective. However, of the 53 studies, only three (6%) implemented schema instruction with children in the early grades (Fuchs et al., 2021, 2022; Powell et al., 2015). Ultimately, the authors determined that interventions combining schema instruction with the concrete-semi-concrete-abstract framework were most effective. Moreover, the addition of metacognitive strategies (e.g., an attack strategy) and graphic organizers increased efficacy.

Myers et al. (2022) conducted another comprehensive meta-analysis on word-problem interventions. Their meta-analysis included 52 experimental group-design studies that implemented word-problem interventions for elementary children (Grades 1–5) with mathematics difficulties. Of the 52 studies, only four (8%) implemented schema instruction with children in the early grades (Fuchs et al., 2021; Huang et al., 2012; Jitendra et al., 1998; Powell et al., 2015). Myers et al. (2022) demonstrated a significant positive effect across all 52 word-problem interventions (g = 1.01 with outliers, g = 0.81 without outliers); however, their meta-analysis did not focus exclusively on schema instruction and included only a handful of studies from the early grades.

Conversely, Peltier and Vannest (2017) conducted a meta-analysis of 21 studies that implemented schema instruction as the primary intervention component. Their meta-analysis included group-design studies that measured the word-problem performance of elementary children (K–6) with or without disabilities. Only two (10%) of the studies implemented schema instruction with children in the early grades (Fuchs et al., 2010; Jitendra et al., 1998). Peltier and Vannest (2017) reported overall positive effects of schema instruction (g = 1.57 for proximal measures; g = 1.09 for distal measures). However, the authors noted a wide distribution of effect sizes across the 21 studies, and their moderator analyses did not include participant grade level(s). Therefore, conclusions about the efficacy of schema instruction within the early grades could not be made.

In 2018, Peltier et al. conducted a meta-analysis of 16 single-case design studies that implemented schema instruction with children identified with disabilities. Among the 16 studies, only three (19%) involved children in the early grades (Peltier & Vannest, 2018; Root et al., 2017; Saunders, 2014). The authors identified schema instruction as an evidence-based practice with strong effects on the mathematics performance of children with learning disabilities (*Tau U* = 88.29%). Participants were categorized into elementary (K–5) or middle/high school (6–12) to investigate whether grade level was a moderator, but participants in the early grades (K–2) and the upper elementary grades (3–5) were not differentiated. Peltier et al. (2018) provided compelling evidence of the effectiveness of schema instruction for children with disabilities across grade levels. However, conclusions could not be made about participants with and without identified disabilities, particularly in the early grades.

Clausen et al. (2021) conducted a systematic review of studies that implemented modified schema-based instruction with children with moderate or severe disabilities. Modified schema-based instruction (MSBI) incorporates color-coded graphic organizers, think-alouds, and scaffolds to increase responses and self-monitoring skills. The authors reviewed 12 studies, two of which (17%) included children in the early grades (Root et al., 2017; Saunders, 2014), and reported a large effect size for MSBI (1.0 *Tau*). This review provided implications for teaching children with moderate to severe disabilities, which cannot be generalized to other populations.

The participants of the studies included in these previous reviews ranged from Grade 1 to 23 years old. The overwhelming majority of studies investigated word-problem performance in the late elementary grades or beyond. Within these reviews, only a handful of studies included children in the early grades. As such, conclusions about the efficacy of schema instruction for young children are limited, restricting both recommendations for future research and implications for classroom practice. With the depth and complexity of word problems in the early elementary grades, evidence-based word-problem interventions must be researched and implemented before deficits widen in the later grades.

Purpose and Research Questions

Although many syntheses have been conducted related to word-problem interventions, some specific to schema instruction, we believe this may be the first effort to specifically synthesize schema instruction in the early grades. First, we identified experimental studies that implemented schema instruction in kindergarten, Grade 1, or Grade 2. We focused on these three grade levels because word problems are introduced in kindergarten, and these grades are often grouped together due to standardized testing beginning in the U.S. in Grade 3. Then, we synthesized the overall effects of schema instruction on the word-problem performance of children in the early grades and described common features and components of the specific interventions. The research questions guiding this systematic review included: (a) How has schema instruction for word problems been applied in the early grades? (b) What is the overall efficacy of schema instruction on the word-problem performance of children in the early grades?

Method

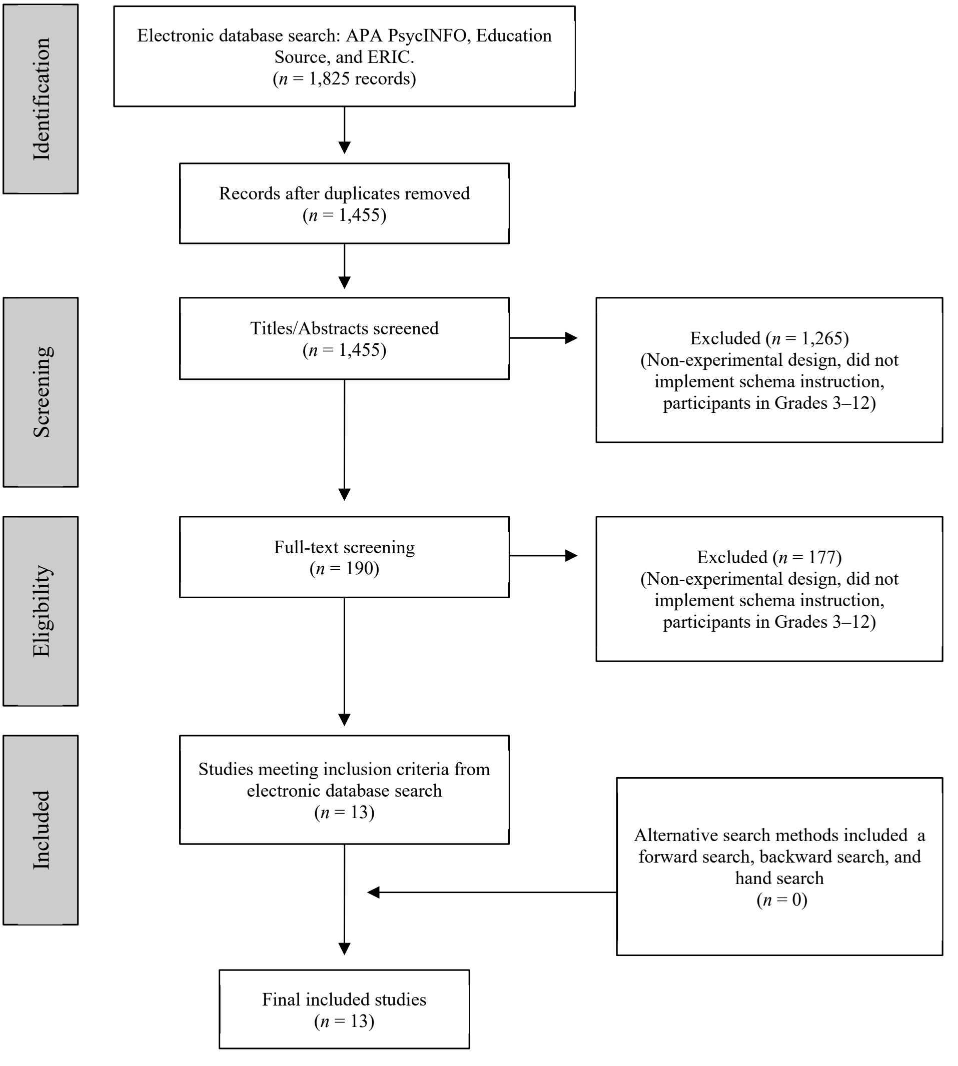
Search Procedures and Results

In May of 2023, the first author searched databases to identify studies that implemented schema instruction in the early grades. Studies of interest measured the effects of schema instruction on the word-problem performance of children in kindergarten, Grade 1, or Grade 2. There was no restriction based on the year of publication. Databases included APA PsycINFO, Education Source, and ERIC. We used the following Boolean Logic to search the full text of records in each database: (total OR group OR combine OR part OR whole OR change OR difference OR compare OR schema OR intervention) AND (“word problem*” OR “story problem*” OR “word-based mathematical question*”) AND (kindergarten OR “first grade*” OR “grade 1” OR “1st grade*” OR “second grade*” OR “grade 2” OR “2nd grade*” OR primary OR elementary). This initial search yielded 1,825 records; after removing duplicates, 1,455 records remained.

After reviewing titles and abstracts, the first author excluded 1,265 records. Many of these exclusions did not use an experimental design, did not implement schema instruction, or only included children in Grades 3 through 12. To assess the reliability of the title and abstract screening, the third author independently reviewed 10% of the 1,455 records. Reliability between the first and third authors was 92%. Among the 12 discrepancies, the third author excluded 10 of the records, whereas the first author included them in the full-text screening. The first author reviewed the full text of the other two records and determined that they did not meet the inclusion criteria. Next, the first author conducted a full-text screening of the remaining 190 records. Overall, 13 studies met the inclusion criteria. The first author conducted a forward search, a backward (i.e., ancestral) search, and a hand search of two prominent journals: the *Journal of Educational Psychology* and *Exceptional Children*. These alternative search methods yielded no additional results. In sum, 13 studies met the inclusion criteria (see Figure 2).

Figure 2

Search Procedure Flow Chart



Inclusion Criteria

We included peer-reviewed studies and dissertations. Studies had to be experimental (i.e., randomized-controlled trial, quasi-experiment, or single-case design). Studies had to measure the effects of schema instruction on the word-problem performance of children in kindergarten, Grade 1, or Grade 2. If the grade level was not reported, we included studies with participants between the ages of 5 and 8. If a study included participants in Grade 3 or beyond, data must have been disaggregated for participants in the early grades. Finally, studies had to be available in English.

Coding Procedures

The first author coded studies for essential characteristics (e.g., sample size, participant grade level, and dosage; see Table 1). Next, the first author coded results and effect sizes descriptively and quantitatively (see Table 2 for group-design studies and Table 3 for single-case studies). Moreover, the first author coded for various intervention components and instructional strategies (e.g., systematic instruction, diagrams, and problem-solving heuristics). Finally, the first author coded quality indicators using Cook et al. (2015). For each quality indicator, the first author used dichotomous scoring (i.e., 1 or 0 for *meets* or *does not meet*). After the initial round of coding, the second author was randomly assigned five of the 13 included studies. The second author reviewed the information in Tables 1, 2, and 3 and indicated agreement or disagreement with 69 units of information. We calculated reliability by dividing the number of agreements by the total units of information the second author reviewed, resulting in a 94.2% reliability. We identified four discrepancies, with no more than one discrepancy associated with an individual study. The discrepancies related to: (a) whether a particular study was an RCT or quasi-experiment, (b) which grade levels were represented in a study, and (c) the descriptions of two word-problem measures. The four identified discrepancies were discussed and resolved.

Results

Description of Included Studies

We included six group-design and seven single-case design studies. Although there were no date restrictions, these 13 studies were published between 2010 and 2022. The majority of the studies were conducted in the United States. One study (Chadli et al., 2018) was conducted in Algeria, and another (Huang et al., 2012) was conducted in Taiwan. Most participants were in Grade 2, and we located zero studies that included kindergarten participants. Several studies included participants in the upper-elementary grades but disaggregated the data to allow for analyses of participants in the early grades. Participants (n ~ 2,100) included children with and at risk for mathematics difficulties, children with autism, intellectual disabilities, and emotional and behavioral disorders, as well as emergent bilinguals and typically-performing children.

Table 1

Summary of Included Studies

Citation	Study Design	Quality Score	Sample Size (K-2)	Intervention Agent(s)	Setting(s)	Grade Level (K-2)	Participants' Status	Schema Instruction Treatment Condition(s)	Included Schema(s)
Bowman et al. (2020)	SCD	100%	n = 1[a]	General education teacher	Individual	Grade 1	Intellectual disability	Teacher-delivered schema instruction (*min not reported*)	Total Change
Chadli et al. (2018)	RCT	54%	n = 52	Technology	Individual	Grade 2	At-risk for MD	Technology-based schema instruction (900 min)	Total Change Difference
Fuchs et al. (2022)	RCT	96%	n = 240	Researcher	Individual	Grade 2	MD	Schema instruction with mathematics-related working memory training items (SI+MWM) (1,350 min) Schema instruction without working memory training (SI without MWM) (1,350 min)	Total Change Difference
Fuchs et al. (2021)	RCT	92%	n = 391	Researcher	Individual	Grade 1	At-risk for MD	Schema instruction with embedded language comprehension instruction (SI+LC) (1,350 min) Schema instruction without embedded language comprehension instruction (SI without LC) (1,350 min)	Total Change Difference
Fuchs et al. (2014)	RCT	92%	n = 1,102	Researcher	Whole group, small group	Grade 2	General education	Two-tiered schema instruction (1,360–2,700 min)	Total Change Difference

Citation	Study Design	Quality Score	Sample Size (K-2)	Intervention Agent(s)	Setting(s)	Grade Level (K-2)	Participants' Status	Schema Instruction Treatment Condition(s)	Included Schema(s)
Fuchs et al. (2010)	RCT	92%	n = 270	Researcher	Whole group	Grade 2	General education	Schema instruction (1,440–1,920 min)	Total Change Difference
Huang et al. (2012)	Quasi	67%	n < 28[b]	Technology	Individual	Grade 2	At-risk for MD	Technology-based schema instruction (240 min)	Total Change Difference
Hughes and Cuevas (2020)	SCD	86%	n = 4[c]	Special education teacher	Individual. small group	Grade 2	Special education	Schema instruction (630 min)	Total Change Difference
Luevano and Collins (2020)	SCD	82%	n = 4	Researcher	Individual, small group	Grade 2	English language learners	Culturally appropriate schema instruction (175–390 min)	Total Change Difference
Peltier and Vannest (2018)	SCD	100%	n = 4	Researcher	Individual	Grade 2	Emotional behavioral disorders	Schema instruction (250 min)	Total Change Difference
Rockwell (2012)	SCD	100%	n = 1[a]	Researcher	Individual	Grade 1	Autism	Schema instruction (930–1,200 min)	Total Change Difference
Root et al. (2017)	SCD	100%	n = 1[a]	Researcher	Individual	Grade 2	Autism and intellectual disability	Schema instruction (150–225 min)	Difference
Saunders (2014)	SCD	95%	n = 2[a]	Researcher, technology	Individual	Grade 2	Autism and intellectual disability	Technology-based schema instruction (200–325 min)	Total Change

Note. RCT = Randomized-controlled trial; Quasi = Quasi-experimental study; SCD = Single-case design study.

[a]Denotes studies that included participants in grade levels outside of K–2, which were excluded from this table.

[b]Huang et al. (2012) included 28 Grade 2 and Grade 3 participants but did not report the distribution of grade levels.

[c]Hughes and Cuevas (2020) provided intervention to 7 participants but only analyzed the data of the 4 due to excessive absences.

Table 2

Group Experimental Studies: Results of Schema Instruction on Word-Problem Solving Accuracy

Citation	Dependent Variable(s)	Word Problem Measure(s)	Descriptive Results	Results/Effect Sizes
Chadli et al. (2018)	Word problems	Mathematical problem-solving test. *No additional details were provided.*	Positive; authors reported SI significantly outperformed BAU.	SI > BAU SI gain = 2.57 points BAU gain = 0.81 points
Fuchs et al. (2022)	Computation Word problems Working memory	*Second-Grade Word Problems:* 12 one- or two-step word problems (total, difference, and change schemas) requiring addition and/or subtraction and aligned with second-grade standards.	Positive; both treatment groups (i.e., schema instruction with *and* without working-memory training) outperformed BAU on the posttest and delayed posttest. *At pretest,* the SI without MWM condition performed 1 *SD below* average- and high-performing classmates. *At posttest,* SI without MWM performed .94 *SD*s *above* classmates.	SI+MWM > BAU (p < .0001), d = 1.36 SI without MWM > BAU (p < .0001), d = 1.51
Fuchs et al. (2021)	Computation Word problems Word-problem language	*First-Grade Word Problems* (Fuchs, Seethaler, et al., 2009): 12 word problems (total, difference, and change schemas) requiring addition or subtraction within 12.	Positive; both treatment groups (i.e., schema instruction with *and* without embedded language comprehension instruction) outperformed BAU. *At pretest,* SI+LC performed 1.54 *SD*s *below* not-at-risk classmates in word problems. *At post-test,* SI+LC performed .51 *SD*s *above* not-at-risk children.	SI+LC > BAU (p < .0001), g = 1.75 SI without LC > BAU (p < .0001), g = 1.08
Fuchs et al. (2014)	Computation Pre-algebraic reasoning Word problems	Proximal measure; *Second-Grade Story Problems* (Fuchs, Powell, et al., 2009): 18 word problems (total, difference, and change schemas) requiring one-digit addition or subtraction.	Positive; authors reported the intervention enhanced word-problem outcomes and pre-algebraic knowledge. On the proximal word-problem measure, SI outperformed BAU. The results of distal word-problem measures were non-significant.	*Second-Grade Story Problems* SI > BAU (p < .001), g = 0.86

Citation	Dependent Variable(s)	Word Problem Measure(s)	Descriptive Results	Results/Effect Sizes
		Distal measure; *KM–Revised Problem Solving* (Connolly, 1998): 18 word problems requiring addition, subtraction, multiplication, and division.		*KM–Revised Problem Solving* SI:BAU *g* = 0.15
		Distal measure; *ITBS*: 22 word problems with both taught and untaught schemas.		*ITBS* SI:BAU *g* = 0.05
Fuchs et al. (2010)	Pre-algebraic reasoning Word problems	Proximal measure; *Second-Grade Vanderbilt Story Problems* (Fuchs & Seethaler, 2008): 18 one- or two-step word problems (total, difference, and change schemas) requiring addition and/or subtraction.	Positive: authors reported superior word-problem learning for SI compared to BAU. SI outperformed BAU on the proximal word-problem measure. The results of the distal word-problem measure were non-significant.	*Second-Grade Vanderbilt Story Problems* SI >BAU *g* = 0.46
		Distal measure; *ITBS Level 8*: 30 one- or two-step word problems (taught and untaught problem types) requiring addition, subtraction, multiplication, or division.		*ITBS Level 8* SI:BAU *g* = 0.27
Huang et al. (2012)	Attitudes about word problems Word problems	A researcher-created assessment including two-digit addition and subtraction word problems. *No additional details were provided.*	Positive; authors reported significantly greater problem-solving ability of SI than BAU at post-test.	SI > BAU SI gain = 3.73 points BAU gain = 0.33 points

Note. SI = Schema instruction; BAU = Business-as-usual; MWM = Mathematics working-memory training items; WP = Word-problem intervention; LC = Imbedded language comprehension instruction; ITBS = the Iowa Test of Basic Skills Level 8–Problem Solving and Data Interpretation (Hoover et al., 1993).

Table 3

Single Case Studies: Results of Schema Instruction on Word-Problem Solving Accuracy

Citation	Dependent Variable(s)	Word Problem Measure(s)	Descriptive Results	K-2 Participant(s)	PND	Additional Assessments
Bowman et al. (2020)	Completion of problem-solving steps Word problems	Researcher-developed probes: 15 one-step word problems (5 trained word problems, 5 untrained word problems, 5 situational generalization probes) with total and change schemas and sums within 5.	Positive; the participant demonstrated a consistent, positive increase in word-problem accuracy. By intervention phase II, the participant completed most probes with an accuracy of 4/5 or 5/5. PND: calculated using correct solutions across all probes and phases.	Alex	70.83%	–
Hughes and Cuevas (2020)	Attitudes about problem solving Frequency of strategy use Word problems	Ongoing word-problem accuracy assessments (Jitendra, 2007): Three to six one- and two-step word problems (total, difference, and change schemas) with sums and differences within 100.	Minimally effective; PND: calculated based on accuracy percentages of the ongoing assessments, across all five units. Of the four children whose data were analyzed, PND varied widely. From pretest to posttest, two participants increased in word problem accuracy, one did not change, and another decreased. However, three children increased strategy use frequency, one of which used the strategy correctly on all attempts. Participants' transfer test scores ranged from 0 to 50%.	Participant 1 Participant 2 Participant 3 Participant 4	38.46% 80.00% 61.54% 0.00%	–
		Pretest and posttest, adapted from Jitendra (2007): Eight one- and two-step word problems (total, difference, and change schemas) with sums and differences within 100.		Participant 1 Participant 2 Participant 3 Participant 4		Pretest/Posttest 37.5% to 37.5% 37.5% to 12.5% 12.5% to 37.5% 0.0% to 50.0%
		Transfer test from the basal math series *enVisionMath 2.0* (Charles et al., 2017): Ten one- and two-step word problems (difference and change schemas) with sums and differences within 100.		Participant 1 Participant 2 Participant 3 Participant 4		Transfer Test 50.0% 0.0% 50.0% 40.0%

Citation	Dependent Variable(s)	Word Problem Measure(s)	Descriptive Results	K-2 Participant(s)	PND	Additional Assessments
Luevano and Collins (2020)	Mathematics vocabulary Word problems	Researcher-developed probe: 30 one-step word problems (total, difference, and change schemas) retrieved from second-grade textbooks requiring addition or subtraction. *1 point for drawing the correct schematic diagram and 1 point for a correct solution.*	Minimally effective; PND: calculated based on correct solutions, suggesting the intervention was successful for two of the four participants. However, all four participants demonstrated improvement in drawing the correct schematic diagrams.	Jessica Adrian Roman Lucie	100.00% 9.09% 0.00% 85.71%	–
Peltier and Vannest (2018)	Word problems	Researcher-developed probes: Baseline, total, difference, change, mixed schema, and maintenance probes included one-step word problems requiring two-digit addition or subtraction without regrouping. Generalization probes included two-step word problems.	Positive; authors reported a functional relation between the intervention and increases in three of the four participants' word-problem accuracy. One participant was able to generate a correct solution for a two-step problem on the generalization probe. PND: calculated based on correct solutions across all probes and phases (including maintenance).	Participant 1 Participant 2 Participant 3 Participant 4	82.61% 100.00% 83.33% 68.75%	–
Rockwell (2012)	Word problems	Researcher-developed problem-solving probes: Nine one-step word problems with the unknown in the final position (total, difference, and change schemas). *1 point for the correct equation and 1 point for the correct solution.*	Positive; the participant reached ceiling level on all word-problem probes, including generalization probes, and maintained performance up to eight weeks following intervention. PND: calculated based on points for correct equations and correct solutions across all phases (i.e., Baseline, Instruction, Follow-Up, Generalization, and Maintenance).	Daniel	*Total* 100.00% *Change* 88.89% *Difference* 100.00%	–
		Researcher-developed generalization probes: Nine one-step word problems with the unknown in various positions (total, difference, and change schemas). Some with an irrelevant quantity. *1 point for the correct equation and 1 point for the correct solution.*		Daniel	*Total* 57.14% *Change* 61.11% *Difference* 0.00%	–

Citation	Dependent Variable(s)	Word Problem Measure(s)	Descriptive Results	K-2 Participant(s)	PND	Additional Assessments
Root et al. (2017)	Completion of problem-solving steps Word problem accuracy	Researcher-developed probes: Three one-step difference problems requiring subtraction within 10. *Assessed using a task analysis. Criterion for mastery: 8/10 points (included accurate solutions for two out of three problems for two consecutive days).*	Positive; at baseline, the participant scored a mean of 6 points across three word problems (30 possible points). Met mastery in eight intervention sessions. During the choice and maintenance phase, the authors reported continued high performance. PND: calculated based on independent completion of steps on the task analysis, across all phases (i.e., Baseline, Intervention, and Choice/Maintenance).	Caleb	100.0%	–
Saunders (2014)	Completion of problem-solving steps Discrimination between word-problem types	Researcher-developed probes: Four one-step word problems (total and change schemas) with sums and differences within 10. Administered using tablets. *Assessed using a task analysis.*	Positive; authors reported a functional relation between the intervention and increases in participants' word-problem solving performance. PND: calculated based on independent completion of steps on the task analysis: up to 24 points for each schema, which included writing the correct answer.	Caleb	*Total* 100% *Change* 100%	–
				Neal	*Total* 100% *Change* 100%	
		Researcher-developed generalization probes: Novel problems (one-step total and change problems with sums and differences within 10) administered in a paper-pencil format. *Assessed using a task analysis.*		Caleb	*Total* 100% *Change* 100%	–
				Neal	*Total* 100% *Change* 100%	

In most studies, the primary researcher or research staff implemented the intervention. Only two of the 13 trained the participants' teachers to implement the intervention. Moreover, most studies implemented one-on-one intervention. Two studies implemented a combination of one-on-one and small-group intervention, one combined whole-group instruction and small-group intervention, and one implemented whole-group instruction. The frequency and duration of intervention sessions varied tremendously among the 13 studies. Some participants received as few as nine sessions, and others received 45 sessions. The frequency of sessions ranged from 2 to 5 times a week, and the duration ranged from 10 to 90 minutes. Overall duration of treatment ranged from 4 to 17 weeks. Table 1 includes overall dosage minutes.

The interventions incorporated a range of word problems. In most of the studies, participants solved one-step word problems. Four of the 13 studies incorporated multi-step word problems. Nine of the 13 studies included a combination of Total, Difference, and Change schemas, and three included a combination of Total and Change schemas. Root et al. (2017), whose participants were children with autism or moderate intellectual disabilities, focused exclusively on solving word problems with the Difference schema. In eight of the 13 studies, participants solved word problems with unknowns in various positions (i.e., the initial, medial, and final positions; see Figure 1). Five studies included word problems with at least one superficial feature (i.e., irrelevant information, relevant information presented in charts or graphs, or multi-step problems with combined schemas; Fuchs et al., 2010).

Computational demands also varied among the 13 studies. Eight of the 13 studies incorporated two-digit addition and subtraction, with and without regrouping. Two studies (Peltier & Vannest, 2018; Rockwell, 2012) incorporated two-digit addition and subtraction *without* regrouping. In several studies with participants who had intellectual disabilities (Bowman et al., 2020; Root et al., 2017; Saunders, 2014), calculations were confined to sums and differences within 10, differences within 10, or sums of less than five.

Quality of the Included Studies

We determined the quality of the 13 studies using the Cook et al. (2015) quality indicators. We assessed the six group-design studies using 24 quality indicators (QIs). Each QI was scored as a 1 (meets) or a 0 (does not meet). The group-design studies met an average of 82% of the QIs with a range of 54 to 96%. (see Table 1). We assessed the seven single-case design studies using 22 QIs (Cook et al., 2015). These studies met an average of 95% of the QIs, with a range of 82 to 100%. Cumulatively, the 13 included studies met 89% of the QIs, suggesting an overall high quality of studies.

Among the group-design studies, many lacked sufficient descriptions of the setting, participant demographics, and control conditions. We considered a description of the setting to be sufficient if it included (a) a geographic location, (b) contextual information about the school or district beyond *elementary school*, and (c) clarity about where the intervention occurred (e.g., in a resource room). For participant demographics, we considered reporting to be sufficient if studies included at least two participant characteristics (e.g., gender and race/ethnicity, or age and socioeconomic status). We considered a description of the control condition to be sufficient if it included any information about how instruction was provided to those students (e.g., the textbook used or the most common instructional strategies). Moreover, some group-design studies lacked specificity in descriptions of word-problem measures or did not report assessment reliability. Another commonly missed QI among the group-design studies related to reporting attrition rates. Finally, among the single-case design studies, the most frequently missed QI related to the timing of outcome measures. Studies received a 1 for this QI if the timings of all measures used in the study were clearly reported.

Treatment Effects

The included studies measured a range of dependent variables, such as mathematics computation and pre-algebraic reasoning, but this systematic review focused on the effects on word-problem performance. Overall, schema instruction positively affected the word-problem performance of children in the early grades. Table 2 provides an overview of the results and effect sizes of the six included group-design studies. Only treatment conditions that implemented schema instruction were included. We described each study's measure of word-problem performance along with the results.

Fuchs et al. (2022) implemented two variations of schema instruction, one with added working-memory training and one without. Participants in both conditions significantly outperformed the business-as-usual group. However, the participants who received schema instruction *without* working-memory training outperformed those who did. The authors of Fuchs et al. (2022) suggested that participants benefited from the increased dosage of schema instruction. Fuchs et al. (2021) implemented schema instruction with and without embedded language-comprehension instruction. Both treatment conditions significantly outperformed the control group. However, participants who received the supplemental language comprehension instruction outperformed those who did not.

Fuchs et al. (2014) and Fuchs et al. (2010) implemented a proximal measure of word problems and a distal measure of word problems. In both studies, participants who received schema instruction performed significantly better than the business-as-usual condition on the proximal measure, but results for the distal measure were insignificant. The authors of Fuchs et al. (2010, 2014) suggested that the multiple-choice format and inclusion of multiplication, division, and fraction concepts (outside the intervention's scope) explained the disconnect.

Chadli et al. (2018) and Huang et al. (2012) implemented computer-assisted interventions. The experimental group in Chadli et al. (2018) significantly outperformed the control group on the posttest. Huang et al. (2012) included Grades 2 and 3 participants. After disaggregating pretest scores, a statistical analysis detected no significant discrepancy between the pre-and posttest scores based on grade level. So, the subsequent analyses were not disaggregated. Overall, participants who received the computer-assisted intervention scored significantly higher on the posttest than the control group.

Table 3 provides an overview of the results of the seven single-case design studies. Each study varied in methods and statistical analyses, so we calculated the percentage of non-overlapping data (PND) for each participant. All single-case design authors reported positive results of schema instruction on participants' word-problem performance, except for Hughes and Cuevas (2020). Hughes and Cuevas (2020) reported schema instruction as minimally effective in improving the seven participants' word-problem performance. The authors of Hughes and Cuevas (2020) suggested that these results were due to off-task behavior related to group size, insufficient instruction on computational skills, and inadequate dosage. When using PND as the measure of effectiveness, the intervention in Luevano and Collins (2020) was also minimally effective. Two participants had PNDs of 85 to 100%, but the other two had PNDs of 0 to 9%. However, the authors reported that all four participants demonstrated an increase in drawing accurate schematic diagrams. Overall, most experimental studies that implemented schema instruction in the early grades achieved positive results regarding word-problem performance. In the next section, we summarize the qualities and components of each schema intervention.

Qualities and Components of Interventions

Schema instruction was not implemented identically across the 13 studies. Root et al. (2017) only focused on one schema. In the other 12 studies that focused on 2 or 3 schemas, the majority (i.e., 8 of the 12) introduced schemas to participants one at a time. Upon introducing a new schema, participants had consecutive opportunities to practice solving those word problems. After receiving consecutive practice opportunities for each schema, participants engaged in interleaved practice opportunities (i.e., solving word problems with mixed schemas). For example, in Fuchs et al. (2022), nine lessons focused on Total problems, nine lessons focused on Difference problems, and nine lessons focused on Change problems. Then, in the last nine lessons, participants engaged in interleaved practice. Alternatively, in four of the 13 studies, participants engaged in interleaved practice throughout the scope of the interventions.

In nine of the 13 studies, participants were explicitly instructed to determine the schema of word problems before solving them. In four of these studies (Fuchs et al., 2010, 2014, 2021, 2022), participants followed the problem-solving heuristic RUN, in which the N stands for "name the problem type." In Hughes and Cuevas (2020), participants followed FOPS, in which the F stands for "find the problem type." In other studies, participants were trained to select and use the appropriate schematic diagram (Luevano & Collins, 2020; Peltier & Vannest, 2018; Rockwell, 2012; Saunders, 2014). Of the studies that did not explicitly instruct participants to determine the schema of word problems before solving, two did not include a wide enough range of schemas to require this step.

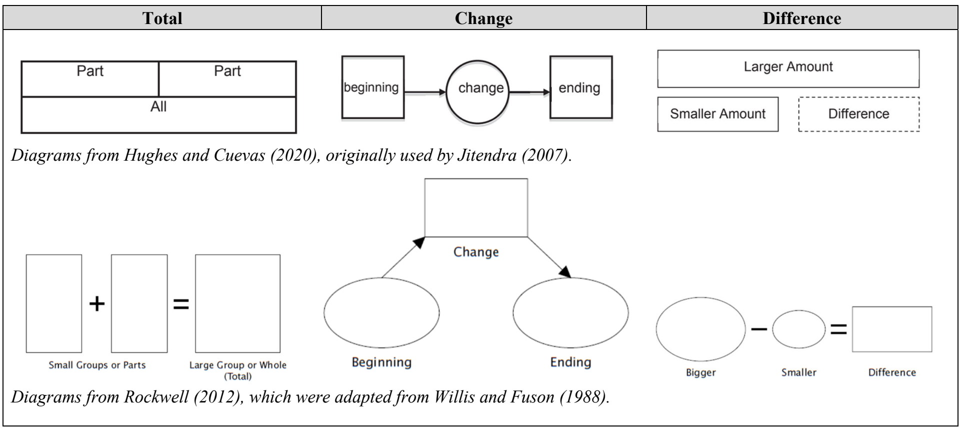
In Bowman et al. (2020), participants learned to solve Total and Change problems limited to sums within five and did not differentiate between the schemas. In Root et al. (2017), participants only solved Difference problems. In Huang et al. (2012), the computerized intervention provided participants with the appropriate schematic diagram depending on the problem type (i.e., Total, Difference, or Change). In the next paragraphs, we describe common instructional components used within the mathematics interventions.

Diagrams and Meta-Equations

All 13 of the studies included diagrams, but to different extents (see Figure 3 for examples). Luevano and Collins (2020) defined schemas *as* graphical representations (i.e., diagrams). In several studies, participants drew diagrams and filled them with the relevant information from the word problem (Hughes & Cuevas, 2020; Peltier & Vannest, 2018; Rockwell, 2012). In others, diagrams were designed to be used with manipulatives and provided to participants. For example, in Bowman et al. (2020), participants used a laminated mat with a diagram large enough for manipulatives to be placed on it. Participants made sets of manipulatives to solve Total and Change problems requiring addition within 5. They placed them in two circles before moving them to a third circle and counting them to find the sum. Root et al. (2017) and Saunders (2014) provided diagrams, and participants used virtual manipulatives.

Figure 3

Examples of Diagrams in Included Studies



Diagrams from Hughes and Cuevas (2020), originally used by Jitendra (2007).

Diagrams from Rockwell (2012), which were adapted from Willis and Fuson (1988).

In four studies (Fuchs et al., 2010, 2014, 2021, 2022), diagrams were used to introduce schemas, but children quickly transitioned to using meta-equations. In meta-equations, letters and mathematical symbols represent the defining features of the schemas (Fuchs et al., 2010). The meta-equations in all four studies were identical. For Total problems, participants wrote P1 + P2 = T (Part 1 plus Part 2 equals the total). For Change problems, participants wrote ST +/− C = E (the starting amount, plus or minus the change amount, equals the end amount). For Difference problems, participants wrote B − s = D (the bigger amount minus the smaller amount equals the difference). Once participants determined a word problem's schema, they wrote the meta-equation. Then, they wrote a new equation, replacing the symbols of the meta-equation with the relevant information from the word problem.

Problem-Solving Heuristic

In ten of the studies, participants followed a specific problem-solving process, often using a heuristic (also referred to as an attack strategy). Four of the 13 studies used the heuristic RUN (**R**ead the problem, **U**nderline what the problem is mostly about, **N**ame the problem type) (Fuchs et al., 2010, 2014, 2021, 2022). Rockwell (2012) implemented RUNS (**R**ead the problem, **U**se a diagram, **N**umber sentence, **S**tate the answer). Peltier and Vannest (2018) implemented STAR (**S**earch the problem by reading it and identifying important information, **T**ranslate the problem into a schematic diagram, **A**nswer the question by identifying the appropriate solution method, **R**eview the solution by assessing reasonableness). Lastly, Hughes and Cuevas (2020) implemented FOPS (**F**ind the problem type, **O**rganize the information using a diagram, **P**lan to solve the problem, **S**olve the problem).

Numberless or Intact Story Problems

Six of the 13 studies implemented numberless or intact story problems to draw attention to the conceptual framework of the particular word problems (Chadli et al., 2018; Fuchs et al., 2014, 2021, 2022; Hughes & Cuevas, 2020; Rockwell, 2012). Numberless word problems include every component of a standard word problem, but instead of including numbers, they refer to general values (e.g., *some* or *more*). Intact story problems include all the numbers, leaving no unknown quantity. Numberless and intact story problems remove the goal of solving a word problem so children can focus their attention on the structure of the story.

Self-Monitoring Behavior Component

Six of the 13 studies included a self-monitoring behavior component. In several studies (Fuchs et al., 2014, 2021, 2022), interventionists set a timer to beep at random intervals to give checkmarks for on-task behavior. Once participants reached a designated number of checkmarks, they chose a small prize. In Peltier and Vannest (2018), participants earned checkmarks for every question they attempted. The participants earned reinforcers they previously confirmed were desirable. Additionally, Saunders (2014) implemented a token-economy system with one participant once the researchers determined the need.

Schema Sorting

To support participants' ability to identify and differentiate between the schemas, five of the 13 studies (Fuchs et al., 2014, 2021, 2022; Peltier & Vannest, 2018; Rockwell, 2012) included sorting activities in which participants read or heard word problems read aloud to them and determined their schema without having to solve them. Additionally, in one of these studies, Peltier and Vannest (2018) began their intervention with two days of instruction devoted to schema identification without solving. Peltier and Vannest (2018) taught participants to use self-questioning to aid in determining the schema of word problems. For Total problems, participants asked, *"Is there a whole value with different parts?"* For Change problems, *"Is there a value changing over time?"* For Difference problems, *"Are two values being compared to one another?"* Similarly, in Saunders (2014), participants used chants with accompanying gestures to help determine the schema. For Total problems, participants chanted *"small group, small group, big group."* For Change problems, participants chanted, *"One thing, add to it OR take away, change."*

Concrete and Virtual Manipulatives

Five of the 13 studies incorporated manipulatives. In Bowman et al. (2020), participants used concrete manipulatives to solve for sums within five for the duration of the intervention. In Root et al. (2017), participants alternated between using concrete and virtual manipulatives to solve Difference problems requiring subtraction within ten. During the concrete manipulatives condition, participants made sets of round plastic disks. Participants used laminated mats with two ten frames to model the greater and lesser numbers. Then, they slid the counters from the greater amount that did not align with those of the lesser amount into a circle labeled "difference." During the virtual condition, participants completed the same steps but with virtual ten frames and blue circles. After the alternating conditions, participants chose between concrete or virtual manipulatives, and all three participants reportedly preferred the virtual manipulatives. In Fuchs et al. (2021), interventionists strengthened participants' conceptual understanding of addition and subtraction using concrete manipulatives. However, they quickly transitioned into teaching participants how to add and subtract within 18 by counting forward across fingers to find both sums and differences.

Explicit Vocabulary Instruction

Four of the 13 studies implemented explicit vocabulary instruction (Fuchs et al., 2014, 2021, 2022; Luevano & Collins, 2020). Fuchs and colleagues taught a wide variety of vocabulary, including "joining words" (e.g., *altogether*, *in all*), superordinate categories (e.g., cats + dogs = pets), "compare words" (e.g., *more*, *fewer*, *taller*, *shorter*), cause and effect conjunctions (e.g., *than*, *because*, *so*), and time passage phrases (e.g., *3 hours later*). In Luevano and Collins (2020), the researchers guided children to identify and define key terms in context and connect them to their own lives.

Gesturing

Three studies incorporated gesturing. In Saunders (2014), participants differentiated between Total and Change problems using chants and accompanying hand gestures. For Total problems, participants made “o” shapes with their left hands and chanted “small group,” followed by doing the same with their right hands. Then, they brought both hands together to make larger “O” shapes and chanted “BIG group” in a deeper voice. The “small groups” represented the *parts,* and the “big group” represented the *total.* For Change problems, participants held up one finger while saying “one.” Then, they flipped their palm up and said “thing.” Next, they pretended to pick items up with their other hand, placing the imaginary items into their open hand while saying, “Add to it.” Then they pretended to remove items from the open hand, saying “OR take away.” Lastly, they moved their open hand from left to right, saying “change.” Fuchs et al. (2021 and 2022) also used hand gestures to teach participants to understand schemas. In these studies, participants learned accompanying gestures for Total, Difference, and Change problems.

Fact Fluency Component

Fuchs et al. (2021 and 2022) included a fact fluency component to support participants in gaining fluency with addition and subtraction. In both studies, participants participated in two one-minute flash card trials per session. The participants were encouraged to retrieve facts from memory, and when necessary, use previously taught counting strategies. The number of correctly answered facts were recorded for both sessions and the higher score was graphed so participants could monitor their improvement over time. In Fuchs et al. (2022), participants’ exposure to addition and subtraction facts was systematic. For the first six sessions, flash cards only included the addition and subtraction of 0, 1, and 2. By the final session, flash cards included addends and minuends up to 18.

Discussion

With this systematic review, we determined schema instruction positively affected the word-problem accuracy of children in Grades 1 and 2. Our results supporting the use of schema instruction were similar to those from other syntheses about word problems. In previous syntheses, authors only included a handful of studies focused on children in the early grades. In our systematic review, we demonstrated that schema instruction is efficacious with some of the youngest learners – children in Grades 1 and 2. Further, the authors of our included studies successfully implemented schema instruction with typically-performing children, children with a range of learning difficulties and disabilities, and emergent bilinguals. As learning disability or difficulty is not often identified by schools in the early grades (Mazzocco & Myers, 2003), it is essential for teachers to have instructional strategies that meet the needs of a variety of learners in the general education mathematics classroom.

Across studies, authors emphasized three schemas with regularity (i.e., Total, Change, and Difference), and children engaged in single- and multi-digit addition and subtraction within the word problems. The focus on these three schemas aligns with the literature on how children develop an understanding of addition and subtraction (Carpenter et al., 1981; Kintsch & Greeno, 1985) and aligns with relevant grade-level standards (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). One author team focused on one schema, but the others focused on two or three. We noted various approaches to introducing each schema, but most children were taught to identify the schema before focusing on the actual solving of the problem.

We identified many shared instructional components as we examined the 13 studies included in this systematic review. All 13 studies incorporated diagrams to aid children in organizing the information in the word problems. The inclusion of such visuals is not a surprise because of the extensive research base in mathematics about representations, such as graphic organizers (Powell et al., 2021). Further, based on the network meta-analysis by Peng et al. (2025), diagrams (e.g., graphic organizers) can increase the efficacy of schema instruction. Often, the diagram represented the conceptual underpinning (i.e., schema) of the word problem. Meta-equations, which were used in several studies, also provided children with a tool to represent the schema of the word problem. Related, three studies incorporated gesturing. Thus, participants associated a specific gesture with each schema that reinforced the structure (e.g., clasping hands together to represent combining parts into a total).

Alongside schema instruction, many of the studies employed a problem-solving heuristic (i.e., attack strategy) to serve as a metacognitive guide as children worked through word problems. Problem-solving heuristics have also been widely researched, both as the focal point of instruction (i.e., general heuristics instruction) and embedded within schema instruction (Myers et al., 2022). Further, incorporating metacognitive strategies, such as an attack strategy, has been shown to increase the efficacy of schema instruction (Peng et al., 2025). The use of an attack strategy may be particularly important for children in the early grades who have had less experience with approaching problem solving than those in the upper elementary grades and beyond. Moreover, introducing children to an attack strategy alongside their first exposure to word problems may prevent children from adopting ineffective strategies, such as plucking the numbers from the word problem and picking an operation indiscriminately.

Nearly half of the studies incorporated numberless or intact story problems, especially when introducing an unfamiliar schema. These specialized word problems draw attention to the underlying structure (i.e., schema) of the word problems without the expectation of solving them. Similarly, five studies incorporated isolated practice in identifying schemas without having to solve the word problems (e.g., a sorting activity).

Several studies included explicit vocabulary instruction. Importantly, vocabulary terms were *not* tied directly to operations (i.e., the problematic, error-fraught keywords strategy; Powell et al., 2022). Instead, authors provided explicit instruction on vocabulary terms that children might encounter in word problems, especially terms that might be important for understanding the schemas of word problems. This focus on vocabulary is important because the correlation between mathematics vocabulary and word-problem solving is strong and positive (Lin et al., 2021). In fact, in Fuchs et al. (2021), children who received schema instruction with embedded vocabulary instruction outperformed children who received schema instruction without embedded vocabulary instruction.

We also noted that several author teams supported children's computation skills within the interventions. Five author teams incorporated manipulatives. This combination of schema instruction with elements of the concrete-semi-concrete-abstract framework is supported by the results of the Peng et al. (2025) network meta-analysis. Further, two studies included a fact-fluency component. To solve word problems accurately, children must draw upon their knowledge of facts or have procedural fluency with a computation strategy to solve for the unknown quantity. Because many children experience difficulty with addition and subtraction facts and computation (Nelson & Powell, 2018), the embedding of this practice within a word-problem intervention may be an important part of word-problem instruction. Ultimately, without fluency with foundational facts and computation, word-problem solving will be more taxing on children's cognitive resources (Fuchs et al., 2006; Kaskens et al., 2022). Thus, it is important to attend to all of the skills required during word-problem solving.

Finally, six of the 13 included studies featured a self-monitoring behavior component. Such components included self-monitoring timers and token economies that rewarded on-task behaviors. It may be particularly important to attend to young children's attention and behavior in the midst of an intervention, as evidenced by these six included studies.

Limitations and Future Directions

Before concluding, we provide a few limitations to this systematic review. First, we may have missed relevant studies. Word problems have been heavily researched for decades, and grade level was the only participant characteristic required for inclusion. There are many terms for schema instruction, as well as different variations of it. Next, we only coded for and discussed the results of word-problem measures. As previously described, word problems are complex tasks and require various knowledge and skills. Due to the multi-component nature of many of the included studies, examining additional dependent variables (e.g., computation skills) could have obtained a broader understanding of the benefits of schema instruction in the early grades. Further syntheses should include a wider range of dependent variables, such as computation skills, pre-algebraic reasoning, and mathematics vocabulary.

The results of this systematic review implicate a few future directions for research on schema instruction. First, although we had no date restrictions on our systematic search, the earliest study to meet our inclusion criteria was Fuchs et al. (2010). This demonstrates that the experimental research base behind implementing schema instruction in the early grades is relatively new. Second, we were unable to locate any experimental studies that implemented schema instruction with kindergarteners. Word problems are introduced in kindergarten, and previous research has supported schema instruction in Grade 1. Future research should test the efficacy of schema instruction in kindergarten. Third, most included studies implemented schema instruction in a one-on-one setting. Additional studies need to implement whole-group schema instruction. Fourth, only one study (Hughes & Cuevas, 2020) used a natural change agent (e.g., a special educator at the research site) as the intervention agent. Most included studies used primary researchers or trained graduate assistants to implement the interventions. Using natural change agents can better measure the true effects of an intervention and garner credibility among practitioners. Lastly, embedding technology within schema instruction requires additional research. Incorporating technology has the potential to increase engagement and can be a helpful tool amid staffing shortages. For example, technology can facilitate engaging, targeted practice with some children while the teacher provides small-group instruction to others.

Implications for Practice

This systematic review can be used as a guide for planning and implementing schema instruction in the early grades. In summary, the results support (a) systematic and explicit instruction on word-problem schemas; (b) diagrams, meta-equations, and gesturing; (c) the use of a problem-solving heuristic; (d) inclusion of numberless or intact story problems and isolated practice with identifying schemas; (e) explicit instruction on mathematics and word-problem specific vocabulary; (f) incorporating concrete or virtual manipulatives and a fact fluency component; and (g) the inclusion of a self-monitoring behavior component.

Conclusion

There is a need for continued research on implementing schema instruction in the early grades, particularly in kindergarten. The results of this systematic review highlight common intervention features both researchers and early childhood teachers could implement. Although more research is needed, there is quality evidence suggesting the benefits of schema instruction for young children.

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