Current Practice ALERTS

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A focus on: **Strategy Instruction That Primes the Problem Structure**

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What Is Strategy Instruction That Primes The Problem Structure?

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Strategy instruction that primes the problem structure is an instructional approach designed to facilitate students' mathematical word problem solving performance. Many students, especially students with learning disabilities (LD), have difficulty with mathematical word problem solving, a complex skill that requires not only retrieving an answer from memory, but also comprehending the text, representing the nature of the problem correctly, planning a strategy, executing the plan, verifying the solution, and monitoring the problem solving processes (Agostino, Johnson, & Pascual-Leone, 2010). These students can benefit from instruction that makes explicit the "underlying structural connections between familiar and unfamiliar problems" (Gersten et al., 2009, p. 26). Typically, arithmetic problems are categorized as belonging to the additive (the solution operation is addition or subtraction) or multiplicative (the solution operation is multiplication or division) problem structure. Strategy instruction that primes the problem structure helps students move from focusing on the superficial features of a problem (e.g., format, vocabulary, irrelevant information) to understanding the problem type or structure and applying known solution methods. In sum, such instruction enables students to become effective strategy users by using representations to make visible the underlying problem structure (e.g., part-part-whole, rate/ratio).

What Are Intervention Approaches For Strategy Instruction That Primes The Problem Structure?

In this Alert, we describe three approaches to strategy instruction that primes the problem structure viewed as effective in the research literature *(see Box 1, page 2)*. These include schema-based instruction (SBI), schema-broadening instruction, and conceptually-based model of problem solving (COMPS). All of these approaches include explicit, systematic instruction to (a) teach students to look beyond superficial surface features (e.g., key words) of problems to focus on the underlying problem structure, (b) apply strategy instruction across a range of problem types, and (c) provide frequent opportunities to categorize and review previously taught problem types. Furthermore, the three approaches scaffold instruction for students using visual aids, such as prompt cards and checklists. The approaches differ with regard to their explicit or implicit emphasis on specific instructional components. For example, SBI and COMPS have incorporated diagrams (e.g., Jitendra et al., 1998, 2007; Xin et al., 2011) but schema-broadening instruction uses concrete materials and role playing to identify the problem type (e.g., Fuchs et al., 2008). And SBI includes additional features such as teacher and student think-alouds with interactive dialogue (e.g., Jitendra et al., 2009) and both SBI and schema-broadening instruction use partner work (e.g., Fuchs, Fuchs, Hamlett, & Appleton, 2002; Jitendra et al., 2007).

For Whom Is It Intended?

Instructional interventions designed to prime the problem structure have been well researched with students with LD and those with or at risk for mathematics difficulties and have been applied successfully with students in elementary school (grades 2-5) (e.g., Fuchs et al., 2009; Jitendra et al., 1998; Xin et al., 2011) and middle school grades (Jitendra et al., 2009, 2011, 2013; Xin et al., 2005). They have both been used to solve both arithmetic word problems (one step and two-step) and complex mathematical problems (e.g., proportional reasoning involving ratios, rates, and percents). Strategy instruction that primes the problem structure can be used not only with students with LD, but also with students with other disabilities, such as speech/language disorders, mild cognitive impairments, emotional/behavioral disorders, attention deficit disorder (e.g., Jitendra et al., 1998), autism (Rockwell, Griffin, & Jones, 2011), and developmental disabilities (Neef, Nelles, Iwata, & Page, 2003). In addition, research

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ABOUT THE AUTHORS

This issue of the *Current Practice Alerts* was written by Asha K. Jitendra and Amy E. Lein in collaboration with the DLD/DR Current Practice Alerts Editorial Committee.

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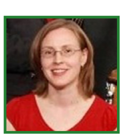

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BOX 1: STRATEGY INSTRUCTION THAT PRIMES THE PROBLEM STRUCTURE INTERVENTION APPROACHES

APPROACH	DESCRIPTION
Schema-Based Instruction (SBI) (e.g., Jitendra et al., 1998, 2007)	Teaching students to (a) identify the underlying problem structure (i.e., Additive Structure – change, group, compare; Multiplicative Structure – ratio, proportion, percent) by focusing on key elements and relations between elements (e.g., part-part-whole) in the problem, (b) use a schema diagram to represent the problem situation, and (c) select an appropriate solution method to solve the problem. Recent studies have also incorporated instruction in metacognitive strategy use to monitor and reflect on the problem solving process and multiple solution methods to promote procedural flexibility.
Schema-Broadening Instruction (e.g., Fuchs et al., 2008)	Teaching students to (a) identify the underlying problem structure (i.e., Additive Structure – change, total, difference) using concrete materials and role playing, (b) sort word problems by problem type, (c) transfer to problems that appear novel due to variation in problem features different from the original problem (e.g., irrelevant information, missing information in different position, information presented in charts, graphs, pictures).
Conceptually-Based Model of Problem Solving (COMPS) (e.g., Xin & Zhang, 2009)	Teaching students to (a) identify the underlying problem structure (i.e., Additive Structure – part-part-whole, additive compare; Multiplicative Structure – equal groups [EG], multiplicative compare) by focusing on key elements (unit rate, number of units, and total or product for EG problems), (b) use story grammar prompt cards to facilitate organizing information using the conceptual model diagram, and (c) use of "algebraic expressions of mathematical relations in a generalizable conceptual model in an equation" (Xin & Zhang, 2009, p. 433).

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BOX 1

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has shown that strategy instruction that primes the problem structure can benefit typically achieving students (e.g., Fuchs, Fuchs, Finelli, Courey, & Hamlett, 2004; Jitendra et al., 2007; Jitendra, Star, Dupuis, & Rodriguez, 2013), as well as students eligible for Title 1 assistance, and students for whom English is a second language (Jitendra et al., 2007).

How Does It Work?

Strategy instruction that primes the problem structure first teaches students to identify the problem type. As Gersten et al. (2009) noted, "problem types are groups of problems with similar mathematical structure" (p. 27). The instruction works by explicitly and systematically teaching students to focus on certain elements (parts, whole) and relations (part-part-whole) specific to the problem situation (e.g., *group*). For example, consider the following *group* problem: *"Farmer Jake has 88 animals on his farm. He only has horses and goats. There are 49 horses on the farm. How many goats are on the farm?"* (Jitendra 2007, p. 78). Students identify that this problem is a *group* problem type, because it involves two distinct parts (i.e., horses and goats) that combine to form a whole (i.e., animals).

Next, instruction facilitates mathematical modeling by teaching students to select relevant relations (e.g., part-part-whole) in the word problem and translate them into a mathematical statement (e.g., part + part = whole). That is, the mathematical situation would be represented as 49 horses + ? goats = 88 animals. In many strategic intervention approaches that prime the problem structure, schematic diagrams facilitate mathematical modeling *(see Box 2, page 3)*. A schematic diagram makes explicit the abstract relationships described in the problem to facilitate understanding and differs from a pictorial or iconic representation, which includes irrelevant features such as the physical appearance of the elements in the problem. For students with LD, who may have cognitive skill deficits in working memory, language, and attentive behavior (e.g., Fuchs et al., 2010), external representations such as a schema diagram to organize information in the problem can reduce the cognitive load, freeing up the mental resources needed to solve word problems. It is important to note that instruction directs students to examine relevant information related to the mathematical structure rather than rely on key words. For example, rather than interpreting "altogether" as a cue to use addition or "left" as a cue to use subtraction, students determine whether to add or subtract in a change problem by noting whether the change amount involves an increase or decrease.

Additionally, students are taught to apply a three or four-step process to monitor and reflect on the problem solving process *(see Box 3, page 4)*. The teacher models these steps using think-aloud procedures or uses story prompt cards while applying each step (e.g., Xin et al., 2011). Diagrams or concrete materials, checklists, and prompt cards support the problem solving instruction and are faded as students are able to apply the strategy independently.

How Adequate is the Research Knowledge Base?

Several systematic reviews examining the effectiveness of strategy instruction that primes the problem structure for students struggling

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BOX 2: SCHEMA DIAGRAM

PROBLEM	DIAGRAM
GROUP: Farmer Jake has 88 animals on his farm. He only has horses and goats. There are 49 horses on the farm. How many goats are on the farm?	Horses 49 + Goats ? = Horses and Goats 88 *Small Groups or Parts* — *Large Group or Whole*

BOX 2

From Jitendra (2007, p. 78). Copyright by Pro-Ed.

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in mathematics have been conducted. The Institute of Education Sciences' research synthesis for struggling students rated interventions that provided instruction on solving word problems based on the common underlying structures as "strong" (Gersten et al., 2009). Xin and Jitendra (1999) reported large mean effect sizes for not only strategy training (d = 0.74, 95% CI = +0.56 to +0.93, n = 12), but also representation of the underlying problem structure (d = 1.77, 95% CI = +1.43 to +2.12, n = 6). A follow-up meta-analysis (Zhang & Xin, 2012) reported a large mean effect size for strategy instruction (d = 1.86, 95% CI = +1.07 to +2.64, n = 12), with strategy instruction that primes the problem structure producing the largest mean effect size (d = 2.64, 95% CI = +1.96 to +3.31, n = 16). Consistent with these meta-analytic findings, a recent evidence-based review reported strong effects for strategy instruction that primes the problem structure among both high quality (weighted mean g = 1.29, 95% CI = +0.86 to +1.72) and acceptable studies (weighted mean g = 1.27, 95% CI = +0.93 to +1.42) (Jitendra et al., 2015).

How Practical Is It?

Strategy instruction that primes the problem structure can be implemented effectively by teachers with a whole class in general education classrooms as Tier 1 core intervention or supplementary Tier 2 or Tier 3 intervention with small groups or individual students as part of the Response to Intervention system of service delivery. Strategy instruction that primes the problem structure needs a commitment of time from teachers to teach in depth the problem solving procedures and for students to apply it successfully to solve novel problems. Researchers have developed scripted teacher materials, including procedural facilitators (e.g., checklists, prompt cards) to support teachers in their implementation of strategy instruction that primes the problem structure (e.g., Jitendra, 2007). When teachers have implemented this type of instruction, fidelity of implementation has been moderate to strong given the use of scripted materials (e.g., Fuchs et al., 2008). Additionally, teachers' perceptions of strategy instruction that primes the problem structure suggest that it is effective, efficient, and applicable to solving a range of problem types (e.g., Jitendra, DiPipi, & Perron-Jones, 2002).

What Questions Remain?

Although strategy instruction that primes the problem structure is an evidence-based practice, questions remain about how best to support the development of problem solving skills involving advanced mathematics content (e.g., proportional reasoning, rational numbers, algebra, geometry) for students in late elementary, middle, and high school. Few studies of strategy instruction that primes the problem structure have been conducted with students with LD at the high school level (Hutchinson, 1993). Other unanswered questions are related to the intensity of instruction. Studies about the length and frequency of instruction to address the needs of students with severe mathematics problem solving and reading problems are not available.

How Do I Learn More?

Here we provide references to books, reports, and articles that present detailed information about strategy instruction that primes the problem structure.

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BOX 3: PROBLEM SOLVING CHECKLISTS

INTERVENTION MODEL	TASK	MNEMONIC	STEPS
Schema-Based Instruction (SBI)	One-step and two-step word problems involving addition and subtraction word problems; ratio, proportion, and percent word problems, including multistep adjustment percent of change problems	FOPS	F = Find the Problem type O = Organize information in the problem using a schema diagram(s) P = Plan to solve the problem S = Solve the problem
		DISC	D = Discover the Problem type I = Identify information in the problem to represent in the schema diagram S = Solve the problem C = Check the answer
Schema-Broadening Instruction	One-step addition and subtraction word problems	RUN	R = Read the Problem U = Underline the question N = Name the problem type
Conceptually-Based Model of Problem Solving (COMPS)	One-step and two-step word problems involving all four operations	DOTS	D = Detect the problem type O = Organize information using the conceptual model diagram T = Transform the diagram into a meaningful math equation S = Solve for the unknown quantity in the equation and check the answer

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About the Alert Series

Current Practice Alerts is a joint publication of the **Division for Learning Disabilities** and the **Division for Research of the Council for Exceptional Children**. The series is intended to provide an authoritative resource concerning the effectiveness of current practices intended for individuals with specific learning disabilities.

Each *Alerts* issue focuses on a single practice or family of practices that is widely used or discussed in the LD field. The *Alert* describes the target practice and provides a critical overview of the existing data regarding its effectiveness for individuals with learning disabilities. Practices judged by the Alerts Editorial Committee to be well validated and reliably used are featured under the rubric of **Go For It**. Those practices judged to have insufficient evidence of effectiveness are featured as **Use Caution**.

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