

Teaching Math With Schema-Based Instruction (SBI)

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In the Spring 2008 Issue of Perspectives, the quarterly publication of IDA, Asha K Jitendra describes a workable way to teach math to LD (indeed all) students. This post is adapted from it.

Since problem solving is not well addressed in many mathematics textbooks, Jitendra and colleagues have developed a conceptual teaching approach that integrates mathematical problem solving and reading comprehension strategies (e.g., reading aloud, paraphrasing, questioning, clarifying and summarizing).

Called “Schema-Based Instruction” (SBI), the system was tested and perfected for a decade. The goal: to improve student learning of word problems, especially students with LD and those at risk for math failure.

In many textbooks, a “keyword” approach is followed.

Too often the same procedure (e.g., addition) is used to solve all problems on a page, and opportunities to discriminate among problems that require different solutions are minimal.

Further, these texts provide students with keywords that ‘send a terribly wrong message about doing math’ (Van de Walle, 2004).

For example, students learn that the keywords in all or altogether suggest using addition, left indicates the use of subtraction, times requires multiplication, or shares indicates that they use division.

The association of keywords with the mathematical operation is problematic in that reliance on these translation cues can lead to systematic errors.

Jitendra offers the example of a problem where “Jose took the 26 baseball cards he no longer wanted and gave them to Brian. Now Jose has 71 baseball cards left. How many baseball cards did Jose have to begin with?”

Children may very well focus on the keyword “left” as well as on the two numbers in the problem and decide to subtract — even though the operation required is addition.

The keyword approach, Jitendra contends, focuses on a “solution strategy.” SBI uses modeling or representing the problem situation; this requires more effort, but accurate problem representation makes sense of the problem by inferring the relations between the objects — a skill critical to successful problem solving.

Other textbooks, in contrast to the keyword approach, use a general heuristic based on Polya’s (1945) four-step problem solving model:

- 1) understand the problem (this can involve asking a series of questions, such as “Do I understand all the words;” “What am I asked to find...”)
- 2) devise a plan (requires selecting an appropriate strategy from a variety of strategies, such as working backward, or using a formula, or looking for a pattern...)
- 3) carry out the plan
- 4) look back and reflect.

In this model, the emphasis is on questioning and discussion.

Jitendra feels this emphasis on multiple strategies may not be the best technique for students struggling in math for several reasons. The *plan* step involves a general approach to the task; the commonly recommended “draw a diagram,” for example, may find LD students generating something that does not properly depict the relations between critical elements.

In addition, although the use of multiple strategies is seen as a means to develop flexible thinking, exposing students with LD to multiple strategies may be an excessive cognitive memory load.

Making Sense of Word Problems Using SBI

Schema-based instruction uses a conceptual teaching approach that integrates mathematical problem solving and reading comprehension strategies.

Jitendra’s research group has developed an intervention program that addresses additive— e.g., *change, group, compare*; and multiplicative structures — e.g., *multiplicative compare, vary, or proportion*. [Note: a problem belongs to the “additive” field when the solution operation is either addition or subtraction; it belongs to the “multiplicative” field when the solution operation is either multiplication or division.]

In addition, the method of instruction is aligned with NCTM Standards: it accentuates the mathematical processes of problem solving: communicating, connecting, reasoning, and representing word problems.

In SBI, problem comprehension/representation (conceptual knowledge) is essential to solving word problems. Such comprehension involves modeling or representing the problem situation, and that requires going beyond direct translation of the problem text — going from words to equations (keyword “altogether” means addition) and to understanding the mathematical problem structure.

Semantic cues — *e.g., both red pens and blue pens are pens* — are used to infer the relations —*e.g., red pens and blue pens are subsets; all pens are supersets* — between objects in the problem text. In this way, students are able to set up the mathematical model —*e.g., n red pens + m blue pens = x pens*.

Based on the mathematical model, students can select an appropriate mathematical operation to solve the problem — *in this example, add to solve for the superset, or subtract to solve for the subset*.

From the perspective of understanding mathematics, it is the linking of the algorithmic procedure —*e.g., adding or subtracting* — to the conceptual idea — *e.g. the sum of the parts is equal to the whole*. This is much more important than knowing that procedure itself.

And so procedural rules —*e.g. add when the whole or total is unknown, subtract when one of the parts are unknown*— in SBI are not taught in isolation, but are linked to the underlying concepts.

SBI also includes several critical features to support students with LD. Instruction is appropriately scaffolded. This means that teacher-mediated instruction is followed by paired partner learning and independent learning activities. Tasks begin with story situations followed by word problems with unknown information. Visual diagrams and checklists are initially provided to support student learning; these are gradually removed or replaced by student constructed diagrams.

“Teacher-mediated instruction” in SBI entails directly modeling problem solving by representing key information in problem texts using schematic diagrams, explaining common rules and procedures, and analyzing students’ solutions and explanations. The schematic diagrams are visual representations that highlight the underlying mathematical structure; they help organize important information in the problem text.

Also, a four-step strategy checklist called FOPS (*F – find the problem type; O – organize the information by using the diagram; P – plan to solve the problem; and S – solve it*) helps anchor the students’ learning.

FOPS serves to foster metacognitive skills and to transition students from teacher-mediated instruction to student self-regulation of strategy use. In particular, students learn to reflect on their understanding of the problem using “think-alouds” —*e.g. “Why is this a CHANGE problem and not a GROUP or COMPARE problem?”*

In addition, this approach permits students to justify the derived solutions using the problem features as anchors for explanations and elaborations, to check the accuracy of not only the computation but also the representation. The intervention ensures that students engage in thinking and reasoning rather than applying rote procedures.

Partner Learning that follows the teacher-mediated instruction uses a Think-Pair-Share model. Students with LD learn to think about the problem type independently and then, with their partner, organize the information and model the problem situation using a schematic diagram. This offers a myriad of opportunities to verbalize strategy steps as they communicate orally with their peers and teachers.

Since students with LD have a tendency to answer problems impulsively, introducing tasks that involve story situations followed by word problems with unknown information ensures that they will reflect on the information rather than just grabbing numbers to compute.

Story situations allow instruction for each problem type —*e.g. “change,” “group,” “multiplicative compare”* — to focus on identifying the problem type and the schematic representation in the diagram. Students learn to interpret and elaborate on the main features of the story situation and infer the relations between the objects in the problem so that all irrelevant information in the story is discarded; problem representation is based on meaningful relations or schematic knowledge.

In addition, SBI incorporates adequate practice and a mixed review of problem types. A sufficient variety of problems is necessary to promote acquisition and generalization of each problem solving skill.

Finally, SBI employs frequent research-validated measures of student word problem-solving performance. This measurement can then inform instruction.

Teachers trained in SBI learn detailed teaching scripts, which they bear in mind but deviate from as they address any misconceptions the student may be demonstrating. Using their own explanations and elaborations — based on the SBI scripts — they support, challenge and scaffold the learning of each individual student.

source: IDA quarterly Perspectives. Find IDA at www.interdys.org. A Spring 2008 article was written by Asha K Jitendra, Rodney Wallace Professor for the Advancement of Teaching and Learning in the Department of Educational Psychology at the University of Minnesota.

Read the complete article for more explanation of the procedures, as well as the types of diagrams used and a sample dialogue with students.

See her recently published curriculum text entitled "Solving Math Word Problems: Teaching Students with Learning Disabilities Using Schema-Based Instruction."

See also "Teaching Mathematics to Middle School Students with Learning Difficulties," by Marjorie Montague and Asha K Jitendra, Guilford Press 2006. ISBN 1593853068. "Provides specific instructional guidance illustrated with vignettes, examples and sample lesson plans. Every chapter is grounded in research."