ABSTRACT: The authors describe how schema-based instruction (SBI), a conceptual teaching approach that integrates the National Council for Teachers of Mathematics (2000) Standards, improved the mathematical problem-solving ability of 2 students with emotional and behavioral disorders (EBD). The authors illustrate the application of SBI to support students as they make sense of, and successfully solve, word problems. Last, the authors report on the factors that may have contributed to the effectiveness of SBI for students with EBD.

KEYWORDS: emotional and behavioral disorders, mathematics, problem-solving ability, schema-based instruction, teaching approach

CHILDREN WITH EMOTIONAL AND BEHAVIORAL DISORDERS (EBD) evidence severe behavioral and academic problems that negatively affect their overall functioning at school (e.g., poor grades, retention, suspensions or expulsions from school). Although research on these students’ academic status has suggested that students perform significantly below grade level in all subject areas, students seem to experience the greatest deficits in mathematics and spelling (Reid, Gonzalez, Nordness, Trout, & Epstein, 2004). Further, deficits in mathematics tend to persist and increase over time (Nelson, Benner, Lane, & Smith, 2004). To date, most instructional interventions in mathematics for students with EBD have targeted basic skills rather than higher level mathematics skills such as problem solving (Hodge, Riccomini, Buford, & Herbst, 2006).

Proficiency in mathematics, in particular, knowing how to reason and solve problems, is crucial to adequately function in the context of daily life situations such as on the job, at home, and in the community. In addition, the National Research Council’s Adding It Up (Kilpatrick, Swafford, & Findell, 2001) report suggested, “All young Americans must learn to think mathematically, and they must think mathematically to learn” (p. 1). For teachers working with students with special needs, the challenge is to shift from a focus on procedural skills and rote procedures to new ways of conceptualizing mathematics instruction to broaden students’ experiences in developing proficiency in mathematics. Central to this instruction is the act of fostering students’ conceptual understanding. One approach that accentuates conceptual understanding and is known to improve students’ problem-solving skills is schema-based instruction (SBI; Jitendra et al., 2007).

What is SBI?

SBI emphasizes the essential role of the mathematical structure of problems as critical to problem comprehension and representation. Instruction highlights problem structure through the use of schematic diagrams that help the learner categorize various problem types and organize information to determine the most appropriate solution procedures. For example, using semantic cues (e.g., both red apples and green apples are apples) and schematic diagrams, SBI involves modeling the problem situation to highlight the relations (red apples and green apples are subsets and all apples are supersets) between objects in

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the problem text. The understanding of those relations is critical to setting up the mathematical model (e.g., \( n \) red apples + \( m \) green apples = \( x \) apples) and selecting an appropriate mathematical operation to solve the problem (add to solve for the superset or subtract to solve for the subset). Because 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) is much more important than knowing that procedure itself, procedural rules (add when the whole or total is unknown; subtract when one of the parts is unknown) in SBI are not taught in isolation. Instead, they are linked to the underlying concepts.

The research by Jitendra and colleagues (e.g., Jitendra et al., 2007) on SBI has resulted in a problem-solving program in which instruction is aligned with the National Council of Teachers of Mathematics (NCTM, 2000). Standards by emphasizing the mathematical processes of problem solving, communicating, connecting, reasoning, and representing word problems (Jitendra, 2007). At the same time, the SBI mathematics program incorporates research-supported instructional practices (e.g., explicit instruction, strategic integration, judicious review) for struggling learners. Specifically, SBI uses a paradigm of teacher-mediated instruction followed by paired partner learning and independent learning activities. It scaffolds student learning using visual diagrams (see Figure 1) and checklists that are eventually faded as students become independent learners. A self-monitoring heuristic or plan (FOPS; in which F represents Find the problem type, O represents Organize the information in the problem using the diagram, P represents Plan to solve the problem, and S represents Solve the problem) is used to anchor student learning in preparation for the transition from teacher-mediated instruction to independent learning (see Figure 2). The FOPS problem-solving heuristic serves to guide students in self-regulating (e.g., “Why is this a change problem?”) their strategy use, justifying the derived solutions using the problem features as anchors for explanations and elaborations, and checking the accuracy of not only the computation but also the representation. These procedures ensure that students engage in thinking and reasoning rather than applying rote procedures. Last, frequent measures of student word problem solving performance that have been validated in previous research (Jitendra, Sczesniak, & Deatline-Buchman, 2005; Leh, Jitendra, Caskie, & Griffin, 2007) are used to monitor student progress and inform instruction.

**Teaching Problem Solving Using SBI**

Although some students are able to translate and integrate information in the problem into a coherent mental representation (Mayer, 1999; Mayer & Hegarty, 1996), students who struggle in mathematics have difficulty with problem comprehension and would benefit from explicit instruction in constructing a model to represent the situation in the text followed by solution planning on the basis of the model (Hegarty, Mayer, & Monk, 1995). SBI is one approach to address these students’ difficulties. Rather than beginning with word problems, each problem schema or problem type for an additive problem structure (e.g., change, group, compare) is presented first as a story situation with no unknown information so that students focus on identifying and representing the features of the story situation using schematic diagrams (see Figure 1). Next, word problems with unknowns that require using either addition or subtraction operation to solve them are introduced. The compare problem “Arthur’s brother, Andrew, is 25 inches tall. He is 8 inches shorter than Arthur. How tall is Arthur?” is used to illustrate the application of the FOPS strategy. As students apply each step of the FOPS strategy (see Figure 2), they learn to monitor their strategy use. The following are the word problem-solving steps.

**Step 1: Find the Problem Type**

To find the problem type, SBI focuses students’ attention on reading the problem and then paraphrasing it in their own words by emphasizing what is known in the problem and what is unknown to understand the problem context. Next, teacher explanations and elaborations of the problem context help students identify it as a compare problem because it involves the comparison of two disjoint sets; that is, the problem compares Andrew’s height to that of his brother, Arthur, and the compare words, “shorter than,” cue the learner to the compare situation in the problem.

**Step 2: Organize the Information in the Problem Using a Compare Diagram**

To facilitate problem representation, students are prompted to use the schematic diagram for organizing or representing the information in the problem text. For the compare problem, it involves reading the comparison sentence (i.e., Andrew is 8 in shorter than Arthur) to identify the two sets compared in the problem, determining the identity of the bigger (Arthur) and smaller (Andrew) sets, labeling them in the diagram for the bigger and smaller sets, and writing the difference amount (8 in) in the diagram. Next, students read the problem to find the quantities associated with the two sets and write them in the diagram (see Figure 1). The unknown quantity in the diagram is represented using a question mark. Last, students summarize the information in the story using the completed diagram and check the accuracy of the representation by reviewing the information related to each set (i.e., bigger, smaller, and difference). In this step, underlining of critical information (e.g., the comparison sentence) and circling of quantities associated with the objects and relations in the problem helps students with attention and memory problems to disregard irrelevant information and focus on the essential information needed to solve the problem.
Step 3: Plan to Solve the Problem

This step emphasizes planning to solve for the unknown quantity by first selecting the appropriate operation. For compare problems, students learn that the bigger set is the whole or total and the smaller set and difference are the two parts that make up the whole. On the basis of this information, they transform the information in the diagram into a number sentence (i.e., $25 + 8 = ?$) even though the semantic equation derived directly from the compare diagram is $? - 25 = 8$. The semantic equation lists the numbers in “the order that follows the meaning of the problem” and may not necessarily isolate the unknown on one side of the equal sign (Van de Walle, 2004, p. 138). As such, by writing an equivalent equation, $25 + 8 = ?$, referred to...
as the computational form of the equation, the unknown is isolated on one side of the equation, which, for students, is easier than the earlier semantic equation to solve.

**Step 4: Solve the Problem**

Last, students solve for the unknown in the math sentence using the operation identified in Step 3 and write the complete answer (i.e., number and unit). They are prompted to check not only the reasonableness of their answer but also the accuracy of their representation and computation. For example, students reason that their answer (i.e., “Andrew is 33 inches tall”) seems right, because Andrew is taller than Arthur, who is 25 inches tall. Also, they check the answer by subtracting $33 - 25 = ?$ (i.e., the difference) or $33 - 8 = ?$ (i.e., the smaller set amount).

**Case Study on SBI Implementation with 2 Students with Emotional and Behavioral Disorders**

Matt and Debbie were two students who were diagnosed with EBD participated in this case study (for a summary of student characteristics, see Table 1). Debbie was diagnosed with severe learning disability in addition to an emotional disturbance.

![Compare problem checklist.](image)

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**TABLE 1. General Description of the Two Case-Study Participants**

<table>
<thead>
<tr>
<th>Description</th>
<th>Matt</th>
<th>Debbie</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Grade</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Race</td>
<td>Caucasian</td>
<td>African American</td>
</tr>
<tr>
<td>Age (in years)</td>
<td>12.0</td>
<td>13.0</td>
</tr>
<tr>
<td>Free/Reduced Lunch</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Diagnosis</td>
<td>Behavioral disorder</td>
<td>Emotional disturbance</td>
</tr>
<tr>
<td>Medication</td>
<td>Yes (5 types)</td>
<td>No</td>
</tr>
<tr>
<td>Cognitive functioning</td>
<td>Borderline to average: verbal IQ 112; performance IQ 72</td>
<td>Average to above average: verbal IQ 112; performance IQ 123</td>
</tr>
<tr>
<td>Achievementa</td>
<td>Math 85</td>
<td>109</td>
</tr>
<tr>
<td></td>
<td>Reading and oral language 97</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Writing 83</td>
<td>82</td>
</tr>
<tr>
<td></td>
<td>Math computation CBM 31 dcpm</td>
<td>28 dcpm</td>
</tr>
<tr>
<td></td>
<td>Reading CBM NA</td>
<td>114 wcpm</td>
</tr>
</tbody>
</table>

*Note. CBM = curriculum-based measurement; dcpm = digits correct per minute; NA = not available.

*aStandard scores on Wechsler Individual Achievement Test II (Psychological Corporation, 2001).*
disorder; Matt had bipolar disorder and exhibited oppositional defiant and disruptive behavior disorders. Both students were receiving instruction from a special education teacher in a private school for children and adolescents with challenging behavior problems. We selected these two students for the case study because they received support from the same teacher in the same classroom. Matt was functioning below grade level in mathematics, and Debbie had chronically underachieved in school. These students were pretested on their mathematics computational skills and were similar in their performance as measured by curriculum-based measurement (see Table 1). The study was implemented over 20 school weeks. Students received SBI in solving one-step and two-step addition and subtraction word problems during their regularly scheduled mathematics instructional period for 45 min daily, 5 days per week, for a total of 225 min weekly. The classroom teacher who received in-service training in implementing SBI taught all lessons with a high degree of treatment implementation fidelity ($M = 98.9\%$; range = 92–100) as determined by independent observations that were conducted nine times during the study.
Case Study Findings

Figure 3 presents the performance data for problem solving by both Matt and Debbie across the study. Matt’s performance on the word problem-solving 16-item test improved substantially from 27% at pretest to 97% for an overall improvement of 70%; Debbie’s performance indicated an increase of 25%. Her scores improved from 73% at pretest to 98% at posttest. Results of an eight-item word problem-solving fluency (WPS-F) probe administered every 3 weeks following instruction to monitor student progress indicated a mean performance of 59% for Matt and 93% for Debbie. For Matt, data during intervention indicated somewhat variable performance, with an increasing trend. Although the performance on the probe at Time 6 showed a decrease, the score was higher than at Time 1 (see Figure 3). In contrast, data for Debbie during the intervention were stable, with an increasing trend. These data are noteworthy given that the progress made by both students during the intervention was either maintained or increased at posttest to a level that is deemed proficient (less than 95% correct). Evidently, proficient levels of performance are necessary for maintenance and generalization of problem solving skills. Further, the mean percentage of on-task behavior during the intervention was 96% for Matt and 97% Debbie, which is encouraging given that students with EBD characteristically experience behavioral problems that interfere with their learning.

Summary

The case study results suggest that students with EBD can successfully learn problem-solving skills when instruction is designed to promote understanding. It appears that the schematic diagrams in SBI provided a “level of concreteness and support to help understand key concepts” (Gersten, 2005, p. 203) necessary for successful problem solving. Three factors seemed to contribute to the effectiveness of SBI for improving the two students’ problem-solving performance in the present case study. Using SBI, the teacher (a) emphasized problem comprehension and representation (conceptual knowledge) as well as linked the algorithmic procedure (e.g., adding and subtracting) to the conceptual idea (e.g., the sum of the parts is equal to the whole), (b) appropriately scaffolded instruction (e.g., consistent, logical, and complete explanations; schematic diagrams; self-regulation strategy checklists), and (c) focused on ongoing progress monitoring to inform subsequent instruction. Although SBI in this case study was effective and represents a promising approach for teachers to meet the provisions of the No Child Left Behind Act (2001) with regard to closing the achievement gap for students with EBD, the intensity of the 20-week intervention for the two students with EBD may call into question the efficiency of SBI. Nonetheless, if the goal of instruction is to promote conceptual understanding, SBI is appropriate because it is one of the few explicit approaches advocated by the National Mathematics Advisory Panel (2008) that addresses effective problem solving and reasoning skills that tend to develop over a long period of time. At the same time, future research with larger samples and rigorous experimental designs should be conducted to determine not only the effectiveness of SBI for improving the problem solving performance of students with EBD, but also to examine transfer effects and outcomes over time.

AUTHOR NOTES

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