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Mathematics Strategy Instruction (SI) for Middle School Students with Learning Disabilities

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One of the greatest challenges teachers currently face with students who are struggling academically is how to provide access to the general education curriculum. The No Child Left Behind Act of 2001 and the Individuals with Disabilities Education Act of 2004 support the assertion that all children, including those with disabilities, should have access to the same curriculum. Furthermore, the National Council of Teachers of Mathematics (2000) supports providing all youth equal access to mathematical concepts. However, students with disabilities in general, and those with learning disabilities (LD) at the middle school level, often have difficulty meeting academic content standards and passing state assessments (Thurlow, Albus, Spicuzza, & Thompson, 1998; Thurlow, Moen, & Wiley, 2005). Specifically, students with LD often have difficulties with mathematics, including basic skills (Algozzine, O'Shea, Crews, & Stoddard, 1987; Cawley, Baker-Kroczynski, & Urban, 1992), algebraic reasoning (Maccini, McNaughton, & Ruhl, 1999) and problem-solving skills (Hutchinson, 1993; Montague, Bos, & Doucette, 1991). Many of these students struggle with how to (a) approach math problems; (b) make effective decisions; and (c) carry out the chosen plan (Maccini & Hughes, 2000; Maccini & Ruhl, 2000).

One effective approach to assisting middle school youth with LD in accessing challenging mathematical concepts is to provide strategy instruction (SI). This brief defines strategy instruction, identifies key features of effective strategies, and identifies key components necessary for instructing youth in the use of a strategy. In addition, we provide a practical example for the use of a math instructional strategy that can be applied to a variety of concepts and settings, and provide some key considerations when using strategy instruction in mathematics classes.

<u>What Is a Strategy and What are the Key Features?</u>

A strategy refers to, "a plan that not only specifies the sequence of needed actions but also consists of critical guidelines and rules related to making effective decisions during a problem solving process" (Ellis & Lenz, 1996, p.24). Some features that make strategies effective for students with LD are:

(a) Memory devices to help students remember the strategy (e.g., a *First Letter Mnemonic,* which is created by forming a word from the beginning letters of other words);

(b) Strategy steps that use familiar words stated simply and concisely and begin with action verbs to facilitate student involvement (e.g., read the problem carefully);

(c) Strategy steps that are sequenced appropriately (i.e., students are cued to read the word problem carefully prior to solving the problem) and lead to the desired outcome (i.e., successfully solving a math problem);

(d) Strategy steps that use prompts to get students to use cognitive abilities (i.e., the critical steps needed in solving a problem); and

(e) Metacognitive strategies that use prompts for monitoring problem solving performance ("Did I check my answer?") (Lenz, Ellis, & Scanlon, 1996).

Some strategies combine several of these features.

STAR is an example of an empirically validated (Maccini & Hughes, 2000; Maccini & Ruhl, 2000) first-letter mnemonic that can help students recall the sequential steps from familiar words used to help solve word problems involving integer numbers.

The steps for STAR include:

(a) **S**earch the word problem;
(b) **T**ranslate the problem;
(c) **A**nswer the problem; and
(d) **R**eview the solution (see Figure 1).

Teachers can use self-monitoring forms or structured worksheets to help students remember and organize important steps and substeps. For example, students can keep track of their problem solving performance by checking off (√) the steps they completed (e.g., "Did I check the reasonableness of my answer?" √).

What Is Strategy Instruction and What are the Key Components in Math?

Strategy instruction involves teaching strategies that are both effective (assisting students with acquiring and generalizing information) and efficient (helping students acquire the information in the least amount of time) (Lenz et al., 1996, p. 6). Student retention and learning is enhanced through the systematic use of effective teaching variables (Rosenshine & Stevens, 1986). That is, certain teaching variables (i.e., review, teacher presentation/modeling, guided practice, independent practice, feedback, and cumulative review) are both effective and efficient for teaching math to secondary students with LD (see Gagnon & Maccini, in press, for a complete description).

Example of Strategy Instruction in Secondary Math:

The example below demonstrates a classroom lesson incorporating the first-letter mnemonic strategy, *STAR* (Maccini, 1998). This strategy incorporates the previously noted strategy features and effective teaching components to help teach the information efficiently and effectively. In addition, the strategy incorporates the concrete-semiconcrete-abstract (CSA) instructional sequence, which gradually advances to abstract ideas using the following progression: (a) concrete stage (i.e., three-dimensional representation in which students manipulate objects to represent math problems); (b) semiconcrete (i.e., two-dimensional representation in which students draw pictures of the math problem); and (c) abstract (i.e., students represent the problem using numerical symbols).

Prior to the lesson, the teacher should pretest students to make sure they have the prerequisite skills and vocabulary relevant to the appropriate math concept(s) and to make sure the strategy is needed. The teacher then introduces the strategy and describes what a strategy is, including the rationale for learning the specific instructional strategy and where and when to apply it. After an explanation, the teacher asks students to explain the purpose of the strategy, how it will help them solve word problems, and how to use the strategy.

Students should memorize the steps of the mnemonic strategy and related substeps for ease of recall by using a rapid-fire rehearsal. This rehearsal technique involves first calling on individual students (or throwing a ball to students) and having them state a strategy step, then repeating the process with other students in the class. The rehearsal becomes faster as students become more fluent with the steps and rely less on teacher prompts or written prompts.

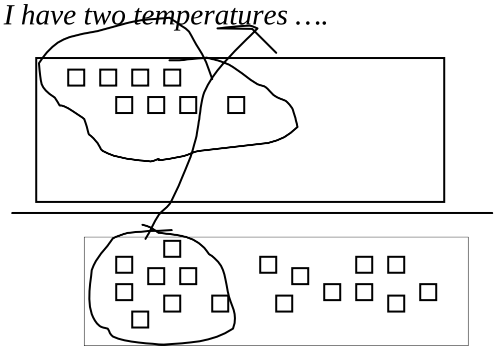
Figure 1: Instructional Steps for a Classroom Lesson

1. Provide an Advance Organizer	The teacher provides an advance organizer of the strategy to help: (a) relate previously mastered information to the new lesson; (b) state the new skill/information that is to be presented; and (c) provide a rationale for learning the new information. **Teacher:** "*Yesterday, we used the problem solving strategy,* STAR*, with word problems involving integer numbers. We used our Algebra tiles to demonstrate the problem and our* STAR *worksheets to keep track of the steps. Today, we are going to use the strategy and draw pictures to demonstrate the problems on our worksheets. This will be useful because we will not always have the math tiles available to help us solve subtraction problems involving integer numbers. It is important to learn how to solve these problems in order to solve many real-world problems, including money and exchange problems, temperature differences, and keeping track of yardage lost or gained in a game."*
2. Provide Teacher Modeling of the Strategy Steps	The teacher first thinks aloud while modeling the use of the strategy with the target problems. Then the teacher checks off the steps and writes down the responses on an overhead version of the structured worksheet, while the students write their responses on individual structured worksheets. Next, the teacher models one or two more problems while gradually fading his or her assistance and prompts and involving the students via questions (e.g., "What do I do first?) and written responses (i.e., having students write down the problems and answers on their structured worksheet). **Teacher:** "*Watch and listen as I solve the problem using the* STAR *strategy and the structured worksheet. The problem states,* On a certain morning in College Park, Maryland, the low temperature was -8°F, and the temperature increased by 17°F by the afternoon. What was the temperature in the afternoon that day?" (See Figure 2 for a copy of the structured worksheet). **S**: *Okay, so the first step in the* STAR *strategy is for me to search the word problem. That means I need to read the problem carefully, and write down what I know and what I need to find. In this problem, I know that I have two temperatures and I need to find the temperature by the afternoon.* **T**: *My next step is to translate the problem into picture form. First, I'll draw 8 tiles in the negative area and then I'll draw 17 tiles in the positive area.* **A**: *Then I need to answer the problem. I know one positive and one negative cancel each other. I can cancel –8 and +8, which results in +9 remaining. Therefore, the answer is +9.* **R**: *Finally, I need to check my answer. OK, I'll reread the word problem and check the reasonableness of my answer. Yes, my answer is +9°F and it is a reasonable answer.*

3. Provide Guided Practice	The teacher provides many opportunities for the students to practice solving a variety of problems using their structured worksheets. Guidance is gradually faded until the students perform the task with few prompts from the teacher.
4. Provide Independent Student Practice	Students perform additional problems without teacher prompts or assistance, and the teacher monitors student performance.
5. Feedback and Correction	The teacher monitors student performance and provides both positive and corrective feedback using the following guidelines: (a) documents student performance (percent correct); (b) checks for error patterns; (c) reteaches if necessary and provides additional problems for students to practice corrections; and (d) closes the session with positive feedback.
6. Program for Generalization	The teacher provides a cumulative review of problems for maintenance over time (weekly, monthly) and provides opportunities for students to generalize the strategy to other problems (see **Figure 3**).

Figure 2: Structured Worksheet of the *STAR* Strategy

Problem: On a certain morning in College Park, Maryland, the low temperature was -8°F, and the temperature increased by 17°F by the afternoon. What was the temperature in the afternoon that day?

Strategy Questions	**Write a check (√) after completing each task:**
Search the word problem (a) Read the problem carefully (b) Ask yourself questions: "What do I know? What do I need to find? (c) Write down the facts	√ ______ √ ______
Translate the words into an equation in picture form	*I know I have two temperatures ….* 
Answer the problem	I can cancel –8 and +8, which leaves me with +9 tiles remaining, therefore, (-8°F + (+17° F) = +9° F ______
Review the Solution (a) Reread the problem (b) Ask yourself questions: "Does the answer make sense? Why? (c) Check the answer	*I checked my answer* √ *(+9 remains when I cancel –8 and +8 and I keep my units of 9 °F)*

What are Some Considerations to Keep in Mind when Using Strategy Instruction in Math Classes?

There are a few recommendations to keep in mind when using strategy instruction in your math class (Miller, 1996; Montague, 1988):

1. *Recognize student characteristics (cognitive and behavioral) and preferences*.
When teaching strategy instruction, be aware of student characteristics and preferences. For example, some students may prefer highlighting relevant words while reading a word problem aloud, while others may prefer underlining and silently reading the problem. Equally important is the need to recognize student behavioral characteristics, including their self-esteem in math and motivation. For instance, students with low motivation may need additional supports to promote active engagement. Examples include creating individual student math contracts with the targeted math objectives and the goal/criterion and promoting active student involvement by having students lead discussions while using a strategy (e.g., "How did you arrive at your solution?").

2. *Promote individualization of strategy instruction (SI)*.
Students should be encouraged to individualize use of SI in math class via adapting a strategy learned in class. For example, as processes involved in the *STAR* strategy becomes more automatic for students, recalling the first step, "Search the word problem," may prompt students to read the problem carefully and to initiate translation into mathematical form (i.e., translating words into an equation).

3. *Program for generalization*.
It is imperative that both special and general education math teachers program for both *near* (i.e., maintaining the same structure but using different story lines) and <u>far</u> generalization (i.e., incorporating more complex problems than the problems in the instructional set) of the SI math strategies in order to promote retention and application of strategy use. For example, for *near generalization*, different story lines can be incorporated for generalization (i.e., use of integer numbers with problems involving time zone changes, sea level, and age) in addition to the problems used in the instructional set. For *far generalization*, more complex problems are introduced than the problems initially taught in the instructional set (e.g., In a certain city, if the difference between the highest and lowest altitude is 155 m and the altitude of the highest point is 900 m above sea level, what is the altitude of the lowest point?). In addition to its application to problem solving involving integer numbers, the *STAR* strategy can be generalized across math topics (see **Figure 3** for an example involving area).

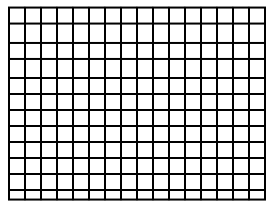
Figure 3: Area Example

Matt is buying wall-to-wall carpeting for his bedroom, which measures 12 feet by 16 feet. If he has $40 to spend, will he have enough money to buy the carpet that costs $2 per square yard?

Search the word problem
(a) Read the problem carefully √
(b) Ask yourself questions: "What do I know? What do I need to find? √
(c) Write down the facts

Matt's bedroom measures 12 ft x 16 ft, has $40 to spend, the carpet costs $2/yd^2, I need to first find the total area of the room…

Translate the words into an equation in picture form



Area of the room
12 ft x 16 ft = 192ft^2

Answer the problem

I know that 3 ft = 1 yd, and (3ft)^2 = (1yd)^2 so 9ft^2 = 1 yd^2. I will ÷192 ft^2 by 9 to get yd^2 = 21.3 yd^2

The carpet costs $2/yd^2, so I will need $2 x 21.3 yd^2 = $42.60. Matt does not have enough money. √

Review the Solution
(a) Reread the problem
(b) Ask yourself questions: "Does the answer make sense? Why?
(c) Check the answer

I checked my answer and it makes sense—Matt needs $2.60 more in order to buy the carpet for his room.

Conclusions

Students with learning disabilities in mathematics often have difficulties deciding how to approach math word problems, making effective procedural decisions, and carrying out specific plans (Maccini & Hughes, 2000; Maccini & Ruhl, 2000). Strategy instruction is an effective method for assisting middle school students with learning disabilities as they complete challenging mathematical problems. To support teacher use of math strategies, this brief defined strategy instruction, and provided key features of effective strategies and instructing youth in the use of a strategy. The practical examples presented illustrate how strategies such as *STAR* can be applied to a variety of math concepts and can provide the support necessary to ensure student success.

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