CHAPTER 10

Addressing Executive Function Problems in Writing

An Example from the Self-Regulated Strategy Development Model

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Over the last 5,000 years, writing has evolved from a recording instrument for keeping track of goods and animals to a flexible and indispensable tool. Writing is now used as a means for communication, a vehicle for learning, and an instrument for artistic, political, spiritual, and self-expression (Graham, 2006a). Writing has become so important today that approximately 85% of the world's population now writes (Swedlow, 1999).

Those who do not learn to write or write well are at a considerable disadvantage. In school, writing is used to gather, remember, and share subject-matter knowledge as well as to explore, organize, and refine ideas about a topic (Durst & Newell, 1989). Thus, students who experience difficulty with writing cannot fully draw on its power to support and extend learning. Their grades are also likely to suffer, especially in classes where writing is the primary means for assessing progress (Graham, 1982).

The consequences of poor writing extend well beyond the schoolhouse. Poor writers are also unlikely to realize their occupational or personal potential. For example, in a survey of 120 American corporations employing nearly 8 million people, writing was identified as a threshold skill for hiring and promoting salaried workers (National Commission on Writing, 2004). A subsequent survey found that writing is even more essential for the nearly 2.7 million state government employees (National Commission on Writing, 2005).

Unfortunately, many children have difficulty mastering this critical skill. Only about 25% of students in the most recent National Assessment of Educational Progress (Persky, Daane, & Jin, 2003) were classified as competent writers. While there are many possible reasons some children do not develop adequate writing skills (see, for example, Graham, in press a; Graham & Harris, 2000; MacArthur, Graham, & Fitzgerald, 2006), one factor that appears to influence writing development and contribute to writing difficulties is executive functioning. We define executive functioning as follows:

> Executive functioning involves the conscious, purposeful, and thoughtful activation, orchestration, monitoring, evaluation, and adaptation of strategic resources, knowledge, skills, and motivational states to achieve a desired goal. This involves analysis (e.g., sizing up the demands of the situation), decision making and planning (e.g., selecting or devising a plan of action), attentional control (focusing and maintaining attention as well as inhibiting interfering behaviors), coordination of cognitive resources, and flexible application (e.g., adjusting plans and goals to meet changing situations).

Skilled writing involves all of the processes that are included in our definition of executive functioning. For example, when Hayes and Flower (1980) asked adults to think aloud while composing, the resulting verbal protocols revealed that skilled writing is a self-directed activity, which is driven by the goals that writers set for what they want to do and say. To meet these goals, the writer must skillfully and flexibly (i.e., thoughtfully) apply and coordinate a variety of resources, including strategic processes (i.e., mental operations for planning, drafting, and revising), knowledge (e.g., about the topic, the intended audience), and skills (handwriting, spelling, sentence construction). The success of this enterprise rests on careful analysis (e.g., determining the demands of the writing task) as well as decision making and planning (e.g., determining a suitable approach to tackling the writing problem). The entire process places considerable demands on the writer's attention, as it requires simultaneously juggling or coordinating a number of constraints and

processes. While motivation received little attention in the initial analyses of Hayes and Flower, this omission was corrected later, when Hayes (1996) emphasized that writers must also attend to affective factors such as goals, predispositions, beliefs, and attitudes when writing.

Even though executive functioning plays a central role in skilled writing, there is surprisingly little research on its function, development, or impact on children who are learning to write. In the next section, we examine a proposition that immature and struggling writers employ an approach to composing that minimizes the role of executive functioning skills in writing.

EXECUTIVE CONTROL AND ITS ROLE IN WRITING DEVELOPMENT AND DIFFICULTIES

The Knowledge-Telling Approach

One of the most important contributions of the work on skilled writing by Hayes and Flower (1980) was the recognition that composition did not necessarily proceed in a linear fashion from planning to drafting to revising. Instead, the skilled writers that they observed acted in a recursive manner, shifting among processes such as planning, drafting, and revising, nesting one within another.

Based upon their extensive observations of novice writers, Bereiter and Scardamalia (1987) indicated that developing or novice writers' approach to composing is much simpler. They primarily convert the writing task into telling what they know about the topic.

The architecture of Bereiter and Scardamalia's (1987) knowledge-telling model includes three components. One component, *mental representation of the assignment*, involves understanding the writing assignment by defining the topic and function of the text to be produced. A second component, *long-term memory*, includes two types of knowledge the writer can draw on to complete the assignment: content knowledge (what the writer knows about the topic) and discourse knowledge (linguistic knowledge and knowledge about the type of text to be produced). The third component, the *knowledge-telling process*, consists of a series of operations. The first two operations are constrained by the writer's mental representation of the assignment and involve making a decision on the topic and type of text to be produced. This serves to guide the writer's search and retrieval from long-term memory. The retrieved information is checked to determine if it matches the nature and topic decided on. If it is appropriate, this information is transcribed into written text. The text produced so far serves as a stimulus for conducting the next search of long-term memory.

For the most part, observations of how immature and struggling writers compose are generally consistent with the knowledge-telling model (e.g., Graham, 1990; Thomas, Englert, & Gregg, 1987). McCutchen (1988) has proposed that these writers adopt and continue to use the knowledge-telling approach because it serves an adaptive function. The process of translating ideas into text (e.g., handwriting, spelling) exerts considerable processing and attentional demands on young writers who have not fully mastered these skills. Executive functioning also requires considerable cognitive effort (Kellogg, 1987). The knowledge-telling approach minimizes (but does not eliminate) the use of executive functioning skills, such as planning and decision making, making writing a less demanding task—one that is less likely to overwhelm a developing writer. It also provides a reasonably successful approach to many of the types of writing tasks young children encounter (e.g., writing about personal experiences, telling what they know about a topic).

As children move from the primary grades to upper elementary school and beyond, writing tasks become more demanding and complicated, requiring a more thoughtful, planful, and reflective approach. In essence, executive functioning becomes more critical to writing success. Many children experience difficulty shedding an approach that requires less effort, especially when it has been relatively successful in the past, for one that requires considerably more. In our opinion, an important goal in writing instruction for developing and struggling writers is to help them upgrade the executive function skills they use when writing. Before presenting a specific approach for enhancing young writers' use of executive functioning skills in writing, we first examine evidence that supports the view that writing performance is influenced by executive functioning skills.

Evidence on the Impact of Executive Functioning on Writing Performance

One method for studying the role of executive functioning in writing is to examine the effects of providing external support in managing and coordinating the elements involved in writing (Graham, 2006a). Focusing on the skill of revising, Scardamalia and Bereiter (1983) provided such support to normally developing students in grades 4, 6, and 8. Students were prompted to use a routine for coordinating and managing the evaluative and tactical decisions involved when revising text. The routine was based on a model of revising involving three elements: compare (detecting a mismatch between what the author intended to say and what was written), diagnose (determining the cause of the mismatch),

and operate (deciding on the type of change needed and carrying it out). This model was operationalized by having students read the first sentence in the first draft of their composition and select the one of a possible 11 evaluations (e.g., "This doesn't sound quite right") that best characterized the sentence (compare stage). Then, they were asked to explain orally how the evaluation applied (diagnose stage). Finally, students selected one of six operations (e.g., "I better say more") that they would carry out (operate stage). This routine ensured that the skills involved in revising occurred in a coordinated way. Providing this procedural support had a positive impact on the revising of the participating students, as they revised more and there was an improvement in the quality of their individual revisions. Similar results were found in a second study with normally achieving students in grades 6 and 12 using a more sophisticated executive control routine (Scardamalia & Bereiter, 1985). Graham and colleagues (De La Paz, Swanson, & Graham, 1998; Graham, 1997) also found that slightly modified versions of these executive control routines enhanced the revising performance of struggling writers with learning difficulties in grades 6 and 8.

These four studies provide support for the proposition that difficulties with executive functioning constrain the revising of normally developing and weaker writers, and there is considerable evidence that teaching executive control routines for planning has a positive and strong effect on the writing performance of these two groups of children. The average effect size for such instruction exceeds 0.80 (Graham, 2006b; Graham & Harris, 2003; Graham & Perrin, 2006). Furthermore, a study by Hooper, Swartz, Wakely, de Kruif, and Montgomery (2002) provides further support for the idea that executive functioning difficulties constrain writing development. They found that weaker writers were less adept than stronger writers on a broad array of executive functioning skills.

In our own intervention research, we made the facilitation and development of executive functioning a central element in how we teach students strategies for planning, drafting, and revising text (see Graham & Harris, 2003). We developed a specific instructional model for teaching these strategies, self-regulated strategy development (SRSD; Graham & Harris, 2005a, 2005b; Harris & Graham, 1996). With this model, students are explicitly and directly taught to apply the target writing strategies and how to use procedures such as goal setting, self-monitoring, self-instruction, and/or self-reinforcement to regulate their use of the writing strategies, the writing task, and their behavior. Content knowledge is increased by teaching students information they will need to use the selected writing strategies and self-regulation procedures effectively. Finally, the model is designed to enhance students' motivation for writing through a variety of procedures, including emphasizing

the role of effort in learning, making the positive effects of instruction concrete and visible, and promoting a "can do" attitude.

We specifically designed the SRSD model so that it would support the following five aspects of executive functioning: analysis, decision making and planning, execution and coordination of mental and affective resources, attentional control, and flexible adaptation. Procedures to support the application and development of these processes are integrated throughout the model's six instructional stages (illustrated in the next section). The SRSD model has proven very effective. In an examination of the writing intervention literature in grades 4–12 (Graham & Perrin, 2006), writing strategy instruction was the most effective writing intervention (average weighted effect size = 0.82), with SRSD being especially potent (average weighted effect size = 1.14).

In the next section, we provide an illustration of how one teacher used the SRSD model to teach second-grade students how to write persuasive text. The six instructional stages of the model are identified as they occur, with the name of the stage in parentheses and italics. This illustration of SRSD is followed by an analysis of how the teacher supported and developed executive functioning via SRSD.

THE SRSD MODEL IN ACTION

Our illustration involves the second-grade class of Ms. Laura Jacobson. She decided to teach a persuasive writing strategy using the SRSD model to her class of 20 students. Included in the class were three students with learning disabilities who struggled with writing and several other students who had difficulty with the writing process. The district's literacy curriculum specified numerous genres to cover at each grade level. To accomplish this, Ms. Jacobson had taught her students a three-step general writing strategy for planning and drafting compositions (POW: *P*ick my ideas; *O*rganize my notes; *W*rite and say more). She had initially taught students how to use this general strategy when writing stories. Students learned to use a genre-specific planning strategy that helped them complete the second step of POW, organize my notes. With the genre-specific planning strategy, students generated and organized possible ideas for the basic parts of a story (e.g., characters, setting, characters' goals). Ms. Jacobson was now ready to move to a second genre, again using POW as the general approach to planning and drafting but introducing a new genre-specific strategy designed specifically for writing persuasive essays.

Before beginning instruction, Ms. Jacobson had her students write a persuasive essay on whether children should have to go outside for recess. She asked students to plan their essay before writing. After col-

lecting the plans and the essays, Ms. Jacobson reviewed her students' work and noted that many of them had difficulty writing persuasive papers, resulting in incomplete arguments. She also realized, that despite already having been taught a general planning strategy (POW), her students were unable to transfer the strategy to help them write their persuasive essay. Her students with learning disabilities exhibited even greater difficulties and had papers that were short and lacked organization and details. These students failed to plan at all; instead, they started writing immediately. Ms. Jacobson set a goal to teach students how to write a persuasive essay that included a topic sentence, three or more supporting reasons, and a good ending. To do this, she used a genre-specific planning strategy (as the organization step of POW) that we had applied in previous studies (see, e.g., Graham, Harris, & Mason, 2005). The strategy TREE reminded students to *T*ell what you believe ("State your topic sentence"), give three or more *R*easons to support your belief ("Why do I believe this?"), *E*nd it ("Wrap it up right"), and *E*xamine your paper ("Do I have all the parts?").

Before starting the persuasive writing instruction, Ms. Jacobson met individually with the students who struggled with writing persuasive essays (*Discuss It*). She discussed each student's previous approach to writing a persuasive essay. Most students said that they wrote down whatever they thought and that they did not engage in any planning. She informed these students that they would learn a new strategy to improve their ability to write a well-organized persuasive essay. This helped prepare them for the upcoming instruction and promote their commitment to learn the strategy. Ms. Jacobson knew that using SRSD to teach narrative writing had helped her students learn to regulate and monitor a writing task effectively, especially her students with learning disabilities. She believed that this strategy would also help her students with this new writing task and excitedly planned for the first lesson.

The first day of instruction started with developing the background knowledge and skills needed to write a good persuasive essay (*Develop Background Knowledge*). Ms. Jacobson first reviewed POW with the class. The class discussed using the POW strategy to write narrative stories. Ms. Jacobson then explained to the students that they would learn how to use POW to write another kind of paper, called persuasive writing. The class discussed the meaning of the words *persuade*, *fact*, and *opinion*; why and when students might want to persuade another; and the goals of persuasive writing. Ms. Jacobson emphasized that good persuasive writing has a topic sentence that states an opinion, three or more reasons to support the topic sentence, and a strong ending. She then introduced the TREE strategy, integrating it within POW by explaining that TREE was used during the "organize my notes" step. To help the

students remember the strategy, the TREE components were compared to a living tree. The topic sentence was compared to the trunk, strong and connected to all other parts; the reasons were like the roots, supporting the trunk; and the ending was like the earth, wrapping around the bottom of the tree. This comparison provided a visual reminder and helped the students understand the reasons for each step. After introducing the strategy, Ms. Jacobson paired each lower-performing student with a higher-performing student to start memorizing the TREE strategy by listing and naming the essential components and describing why each was important (*Memorize It*). The students used cue cards during this introduction to the strategy.

During the next lesson, Ms. Jacobson emphasized the goals of writing better persuasive papers and the necessity of student effort to use and apply the strategy while writing (*Discuss It*). She explained how learning this strategy would enable students to write good persuasive essays. The class then established goals for learning the strategy, and made a commitment to learn it. At the end of the lesson, Ms. Jacobson again paired the students (lower- with higher-performing students) and established writing partners. The writing partner activity was designed to help students transfer the writing strategy to other writing tasks. Ms. Jacobson explained that the writing partners would help each other identify situations when part or all of the strategy could be transferred to other writing tasks, as well as provide help or reminders to use the strategy.

The next day, Ms. Jacobson discussed the parts of a persuasive essay, focusing on the topic sentence and supporting reasons (*Develop Background Knowledge*). She then read aloud an example of a persuasive essay while students followed along on paper. Students raised their hands when they heard one of the TREE components. After identifying the topic sentence, students underlined it on their copy. Ms. Jacobson also included a discussion about transition words, and the students circled the transition words on their copy. The class discussed how transition words help a reader find the reasons in a paper. The students located and labeled each reason with a number, then counted the total number of transition words and reasons in the paper. Finally, the students identified and underlined the end sentence.

Next, Ms. Jacobson introduced the TREE graphic organizer. She demonstrated how to write all of the TREE components from the example essay in note form on the organizer, numbering the reasons as she wrote. Students helped locate the TREE parts in the essay for Ms. Jacobson to write on the graphic organizer. After the topic sentence, reasons, and endings were recorded, Ms. Jacobson then examined the paper to ensure all parts were complete. Students continued to memorize the strategy by working in pairs to practice writing the TREE reminder

(*Memorize It*). This practice activity was continued until each student could name the reminder (TREE) and write the parts on paper from memory. Ms. Jacobson provided additional support and practice for the students with learning disabilities and other struggling writers in the classroom.

During the next lesson, Ms Jacobson introduced self-monitoring and graphing. She asked the students to analyze their previously written persuasive papers on whether children should have to go outside for recess. Ms. Jacobson demonstrated how to read through the paper, using the TREE reminder to look for a topic sentence, three or more reasons, and an ending. She illustrated how to graph each of the parts, which involved coloring in a piece of a rocket for each part in the paper. The students worked on graphing the parts of their papers, while Ms. Jacobson circulated to ensure that everyone was graphing correctly. The students discussed the parts in their papers and which parts to remember to include the next time (*Discuss It*). Ms. Jacobson emphasized that even if a component was included, students could improve it by adding more details or examples to support their reasons or using more sophisticated vocabulary, which she called million-dollar words.

At the end of this lesson, the students met with their writing partners. In a group, the class brainstormed ways to use all or part of the POW or TREE strategy. They discussed how TREE was different from the previously learned narrative writing strategy. They talked about how to transfer the strategies to other writing tasks, such as letters to friends, writing to convince someone, and reports. They also discussed what to do if all or part of the strategy did not work, such as changing parts of TREE or not using TREE if it did not make sense for that writing task. The students made a goal of reporting to their writing partners in the next lesson on how they transferred their strategies. Ms. Jacobson reviewed a chart that helped students record how they transferred their strategy and how they helped their partner transfer the strategy.

In the next lesson, students initially met with their writing partners to complete their "I transferred my strategies/I helped my partner" chart. Ms. Jacobson verbally reinforced each student's effort. The class talked about how they tried to transfer their strategies and the success of their attempts and brainstormed ways to work out problems when transferring strategies, such as asking a writing partner or trying to change some parts of the strategy. Ms. Jacobson established a routine of starting each lesson with the writing partners filling out their charts and a short discussion to guide students through the problems encountered in the transfer task.

During the main part of this lesson, Ms. Jacobson read two more persuasive essays and helped the students verbally identify the parts of the paper (*Develop Background Knowledge*). She showed students how to write their ideas in note form. She then asked the students to add one or two additional reasons to the paper, and she listed these reasons on the graphic organizer. The students were asked to think of transition words for the additional reasons. At the end of the lesson, the group revisited their goal of learning the POW + TREE strategy, including all of the TREE parts and improving all of the parts each time they wrote a persuasive paper.

The following day, Ms. Jacobson posted a copy of POW + TREE, along with the topic "Should students have to give away some of their toys to children who don't have any toys?" Ms. Jacobson modeled how to brainstorm ideas during the "pick my ideas" phase of writing (*Model It*). While modeling, she talked aloud about brainstorming, saying, "I have to let my mind be free. I will take my time, and a good idea will come to me." Ms. Jacobson thought aloud about her ideas on this topic and then decided that her topic sentence would agree that students should have to give toys to children who do not have any. She also modeled brainstorming reasons to support this topic sentence.

During the "organize my notes" phase, Ms. Jacobson modeled how to use the TREE graphic organizer, thinking aloud to develop the essay. Before starting, she set a goal of including all TREE components while writing. During this activity, the students participated by helping Ms. Jacobson plan and make notes for each part. After the "organize my notes" phase was complete, Ms. Jacobson modeled the "write and say more" step using the graphic organizer. She continued to think aloud on how to include the topic sentence, three or more reasons, and an ending. Ms. Jacobson also modeled the recursive nature of writing by making changes to her plan during the writing phase. She remembered to include transition words and used self-statements or questions to help herself organize, stay on task, and address negative self-statements. Ms. Jacobson included self-statements about problem definition ("What do I need to do?"), planning ("First, I need to think of a topic sentence"), self-evaluation ("Does this reason support the topic sentence?"), self-reinforcement ("That is a great reason!"), and coping ("I can do this"). After the first draft was written, the class examined the draft to check if all of the TREE components were present. Ms. Jacobson then verbally reinforced herself for reaching her goal and charted her progress on the graph.

Next, the class discussed the importance of the self-statements people, including Ms. Jacobson, make while writing. Some students offered examples of their own self-statements, and Ms. Jacobson asked the students to identify some self-statements she had made while she was writing. The students then brainstormed a list of positive self-statements.

Ms. Jacobson made sure to address the areas of problem definition, planning, self-evaluation, self-reinforcement, and coping. Each student developed his or her own positive self-statements and recorded them on a card to use while writing. Ms. Jacobson worked with the students in her class who tended to write very little to help them develop positive self-reinforcement and coping statements when discouraged or frustrated with the writing task.

The following day, Ms. Jacobson continued to model the POW + TREE strategy to write a persuasive essay about the topic "Should students have to go to school in the summer?" She followed the modeling procedures in the previous lesson, but in this lesson she encouraged students to take the lead as much as possible. While Ms. Jacobson modeled the process, the students wrote their own notes on a graphic organizer. The class worked through the POW + TREE strategy, focusing on both the process and the self-statements made during the writing process. After the class generated the notes for the paper, they reviewed them to see if they could add more. The students then wrote individual persuasive essays using the class-generated notes (*Support It*). A transition word chart was provided to help students use transition words in the persuasive essay. Ms. Jacobson also encouraged them to use their self-statements as they wrote.

To ensure student success during this phase of instruction (i.e., *Support It*), Ms. Jacobson individualized her support based on student needs. She encouraged more proficient writers to add million-dollar vocabulary words and examples to support their reasons. She conducted a small-group mini-lesson for the students with learning disabilities and the other struggling writers. She had noticed in previous lessons that they continued to require more modeling and support before they could try writing independently. During the mini-lesson, she intentionally forgot a strategy step, and the students discussed the impact and cause of errors. Ms. Jacobson knew these students frequently had difficulty remembering all of the steps of the writing task. She modeled how to remedy the problem and remain focused on the task rather than quitting. Another important lesson for these students was learning to focus on the important attributes of the writing task. Ms. Jacobson modeled how to pay attention to the steps of the POW + TREE writing strategy, rather than attending to the mechanical aspects of writing such as spelling and handwriting. She had seen in the past that many of her struggling writers had difficulty with spelling and handwriting and tended to focus their attention on these skills rather than the higher-level skills of planning and organizing. The small group worked together to generate a paper on the day's topic. At the end of the lesson, all students examined the paper and graphed their progress.

The next week consisted of more collaborative practice with several persuasive writing prompts (*Support It*). Ms. Jacobson continued to monitor individual student progress and provide small-group mini-lessons to children to individualize instruction based on student needs. For the students with learning disabilities, she gradually faded support from modeling the planning phase to reminders to use specific steps. She then faded more support by only providing prompts to pay attention to a specific step. After each paper was completed, students examined their essays and graphed their progress. She allowed students to work at their own pace, as she recognized that her students with learning disabilities required more time to finish a paper. After 2 weeks of practice, most students were proficient in writing a persuasive essay that had a topic sentence, three or more reasons, and a good ending. The students with learning disabilities still required cue cards, transition word charts, and self-statement cards to move through the writing process, but they now required less teacher assistance. At this point, Ms. Jacobson weaned her higher-performing students from the graphic organizers and the graphing process. She taught them how to take notes on blank paper by writing the POW + TREE reminder at the top of the page rather than using the graphic organizer. She also modeled how to make a space for notes on each part of the TREE writing prompt.

Once her students were able to list and describe the POW + TREE components and write a persuasive essay with all of the parts, Ms. Jacobson ended her unit on persuasive writing with two transfer tasks (*Independent Practice*). Before starting the last phase of instruction, she asked the writing partners to share ways they had transferred the POW + TREE writing strategy or some part of it in the last several weeks. Students provided examples of situations in which they were able to transfer the strategy and examples of unsuccessful attempts to transfer the strategy. In the first transfer task, the students read a short story about the Little Red Hen. At the end of the story, Ms. Jacobson asked, "Would you have helped the Little Red Hen? Write a paper telling why or why not." The class discussed whether the POW + TREE writing strategy would work for this paper and the similarities to and differences from previous prompts. At the end of the discussion, the class determined that the POW + TREE strategy would work for this paper. The students worked independently on this writing task, and Ms. Jacobson provided individual support as needed.

The last lesson in the unit focused on individualizing the prompts and self-statements. Ms. Jacobson wanted her students to personalize the strategy in useful ways and to realize that the action plan was flexible and modifiable based on the specifics of the writing task. The class discussed how to improve the strategy and shared with each other the

parts that worked best for them. Ms. Jacobson realized that some of her stronger students were able to drop steps of the strategy and still write proficient papers, but some of her struggling writers, especially the students with learning disabilities, continued to require much of the support provided by the graphic organizers. The students were no longer required to use the goal-setting and progress-monitoring pieces but were encouraged to continue using them if necessary to help them meet their goals. As a final writing assignment, the class completed the second transfer task based on a story about the Roman hero Hercules. At the end of the story, Ms. Jacobson asked, "Should Hercules help the old man? Write a paper telling why or why not." After the persuasive essay was finished, the class celebrated their success in learning to write a good persuasive essay and agreed to participate in review sessions to help promote maintenance and generalization.

How SRSD Addressed Problems in Executive Function and Facilitated Its Development

SRSD includes instructional procedures that address problems in executive function, as defined earlier in this chapter. Specifically, SRSD addresses the following aspects of executive function: analysis, decision making and planning, execution and coordination of mental and affective resources, attentional control, and flexible adaptation. The next section provides a representative sample of common instructional procedures included in SRSD (as applied by Ms. Jacobson) that address aspects of executive function involved in the writing process.

Analysis

An important aspect of analysis in writing involves defining the problem and identifying the necessary elements of the task. SRSD incorporates such task analysis by explicitly teaching students how to define the problem and the elements of a writing task. Ms. Jacobson discussed the goals of persuasive writing during the *Develop Background Knowledge* and *Discuss It* stages. The elements of persuasive writing were compared and contrasted to the elements of narrative writing, a previously mastered genre. This discussion helped students identify situations in which writing a persuasive paper using the TREE strategy would be appropriate. Next, Ms. Jacobson modeled how to define the problem and identify the elements of the task specific to persuasive writing (*Model It* stage). Students were then given opportunities to practice these skills during the *Support It* and *Independent Practice* stages of SRSD. Ms. Jacobson had noted that her students with learning disabilities tended to writing

immediately begin, before defining the problem and identifying the elements of the writing task, and were thus unable to determine an appropriate approach to the task. Discussing, modeling, and supporting task analysis were critical for these struggling writers to help them differentiate among the elements of different writing tasks.

Generalization and transfer of task analysis were promoted by having students work with writing partners to identify elements of other writing tasks that lent themselves to using all or part of POW + TREE. Each day, the writing partners met to discuss previous opportunities to transfer their strategies to another writing task. During this time, the partners helped each other identify the elements of writing tasks that were appropriate for using all or part of the POW + TREE writing strategy. The writing partners were encouraged to define the problem of a specific writing task and to analyze whether the strategy would work.

Decision Making and Planning

Decision making and planning in writing require goal setting, making a decision to plan, exploring possible approaches and outcomes, and selecting or devising a plan of action. These skills are critical for skilled writing; however, they can be overwhelming to students with learning disabilities who already face a taxing cognitive load. The handwriting and spelling demands for these students are often so demanding that their decision-making and planning abilities are minimized (McCutchen, 1988). SRSD's instructional procedures explicitly model decision-making and planning skills while scaffolding instruction until students are able to perform these tasks independently.

Ms. Jacobson addressed goal setting before starting persuasive writing instruction. She held individual conferences with the students with learning disabilities and her other struggling writers, in which they discussed their previous approaches to persuasive writing and began the process of setting goals to learn the strategy. For the students with learning disabilities, this process highlighted the contrast between their previous ineffective approaches and the new approach, providing an incentive for students to buy into the benefits of the strategy. With the entire class, Ms. Jacobson introduced goal setting throughout the SRSD process. Students set a goal to learn the POW + TREE strategy and engaged in daily practice to learn and describe the strategy components and to include all of the parts in their persuasive essay (*Memorize It*; *Discuss It*). Ms. Jacobson also promoted flexible goal setting by encouraging students to modify their goals as they became more proficient in using the strategy. This process of goal setting helped boost motivation and increase persistence for the struggling writers (Graham & Harris, 1994).

SRSD also includes a series of steps that encourage students to be deliberate in their prewriting phase. Many beginning writers fail to plan or to consider the organization of their essay (Graham & Harris, 1997; Hillocks, 1984). Ms. Jacobson explicitly modeled how to make a decision to plan, explore possible approaches, and then select a plan of action (POW + TREE) to write a persuasive essay. Again, students were given opportunities to master these planning skills during the *Support It* and *Independent Practice* stages of SRSD. This action plan is especially powerful for students with learning disabilities and other struggling writers, who often approach academic tasks in an ineffective or inefficient manner (Harris, 1982), and increases the likelihood that students will incorporate the planning strategy into their existing writing routine (Graham & Harris, 2005b).

Execution and Coordination of Mental and Affective Resources

Writing tasks are inherently complex and require planning, drafting, and revising skills, all of which depend on basic reading, language, spelling, and handwriting skills, as well as knowledge, metacognition, attitudes, motivation, and memory processes (Abbott & Berninger, 1993; Hayes, 1996; Hayes & Flower, 1980; Kellogg, 1987; Scardamalia & Bereiter, 1987). In addition, each written composition is framed by the expected genre, goals, and needs of its audience. SRSD incorporates instructional procedures to support the execution and orchestration of cognitive, metacognitive, and affective resources necessary to carry out multiple demands in writing tasks.

Ms. Jacobson made sure students had the skills and knowledge needed to executive the strategy effectively. (*Develop Background Knowledge*) she introduced the goals and components of a good persuasive essay, as well as important vocabulary words such as *fact*, *opinion*, and *persuade*. This knowledge of the task was further strengthened during the *Model It*, *Support It*, and *Independent Practice* stages as students received help writing persuasive essays.

Another way SRSD strengthens execution and orchestration of resources is by incorporating several stages of strategy development. Students memorize the strategy, observe it modeled several times, receive scaffolded support based on individual needs, and engage in independent practice once the strategy has been mastered. This process improves students' knowledge of how to write a good persuasive essay and is designed to support them until they are able to be successful on their own. SRSD is both individualized and criterion-based, meaning that students receive instruction tailored to their needs and do not proceed to the next stage until they have met criteria for doing so. Ms. Jacobson addressed this requirement by allowing students to work at their own pace and conducting mini-lessons with small groups of children who required similar support. For the struggling writers, mini-lessons featured more modeling and support, while mini-lessons for higher-performing students taught more advanced skills.

SRSD also incorporates self-regulation components, which are thought to be important in skilled writing due to the complexity of the writing process (Zimmerman & Riesemberg, 1997). Ms. Jacobson modeled and taught the use of self-statements to monitor and regulate cognitive, metacognitive, and affective resources, addressing the areas of problem definition, planning, self-evaluation, self-reinforcement, and coping. Students were further encouraged to personalize their self-statements to their problem areas. Ms. Jacobson worked with the students with learning disabilities to help them first develop self-statements related to self-reinforcement and coping, since she had seen that these students had negative attitudes about writing and gave up easily. Once these students were able to sustain effort throughout the writing task, they added other self-statements related to the cognitive and metacognitive aspects of the task, such as problem definition and planning.

Attentional Control

Due to the complexity of writing, attentional control is an important component of the composing process. Skilled writers delay responding and put aside typical approaches that may be ineffective. They must also inhibit interfering behaviors and focus on the important attributes of the task. Finally, they must be able to sustain their effort and attention throughout the writing process.

Ms. Jacobson noticed that many of the students with learning disabilities had difficulty sustaining effort and attention while writing. Students with learning disabilities and other struggling writers often have difficulties with transcription skills, such as handwriting and spelling (Graham, Harris, MacArthur, & Schwartz, 1991), which consume a great deal of attention while composing (Berninger, 1999; Graham, 1999; Graham & Harris, 2000). Having to concentrate on the mechanical aspects of writing inhibits students' abilities to focus on the planning and content generation of the paper (Graham, Schwartz, & MacArthur, 1993). This focus on transcription skills leads students to judge writing quality as good handwriting and spelling rather than the organization and substance of the paper (Graham, 1992; Graham et al., 1993).

The instructional procedures in SRSD helped Ms. Jacobson strengthen her students' attentional control. She started by asking students to make a commitment to learn the new strategy. She emphasized that learning a new strategy requires substantial effort. At this time, she also stressed the benefits of learning the strategy to motivate students throughout the process. She provided a supportive environment by expressing her belief that all students would be able to learn the strategy and write good persuasive essays. As students progressed through SRSD stages, they charted their progress, which enabled them to see the benefits of using the strategy. Their motivation to continue using the strategy increased, thereby improving their ability to maintain attentional focus.

The use of specific strategies such as POW + TREE increases student attention to the essential components of the writing task. Using the graphic organizer for TREE taught students to focus on the essential components: the topic sentence, reasons supporting the topic sentence, and a good ending. It also directed students to examine their paper afterward to ensure that all of the parts were present. Ms. Jacobson addressed students' concerns about good handwriting and spelling by incorporating a draft process in which they were able to rewrite their paper to improve the spelling and handwriting. Students were able to maintain their focus on the essential components of the writing task, knowing that they could rewrite their paper later.

While students were learning the persuasive writing strategy, Ms. Jacobson provided visual cues, prompts, and cue cards, along with graphic organizers and graphing sheets to help them maneuver through the writing process. As they became more proficient in their ability to manage this process, Ms. Jacobson slowly removed the visual supports and taught students to make their own cues and prompts.

The use of personalized self-statements also helped students improve their attentional control. Ms. Jacobson first modeled the use of self-statements on problem definition, planning, self-evaluation, self-reinforcement, and coping. She then led a discussion about the benefits of self-statements and had students develop their own to address individual challenges. Ms. Jacobson made sure that the students with learning disabilities and other struggling writers had simple self-statements that addressed sustaining effort and positive reinforcement, as she had noticed that these students tended to have a negative attitude about writing and were therefore prone to giving up quickly. The students reviewed their self-statements each lesson, and the self-statements were always available to them while they were writing. Ms. Jacobson continued to model the use of self-statements during whole-group and small-group mini-lessons to demonstrate how they could help students focus on the writing process.

Flexible Adaptation

The writing process requires flexible adaptation; skilled writers monitor, evaluate, and modify their use of specific writing strategies based on their past and present success (Zimmerman & Riesemberg, 1997). Writing plans and goals may need to be adjusted to meet changing situations or new information. Flexible adaptation is also essential for transfer and generalization of strategy use.

Ms. Jacobson's use of SRSD to teach several different writing strategies addressed flexible adaptation in several ways. First, Ms. Jacobson explicitly taught transfer by linking the general planning strategy (POW) to a new genre-specific strategy (TREE). Students in her class had previously learned to use POW with narrative writing and were able to transfer this strategy to a new genre. Using the same general writing strategy to teach multiple genre styles greatly enhanced her students' ability to monitor, evaluate, and adapt the strategy in several writing situations.

Second, Ms. Jacobson set up writing partners to help focus students on using all or part of POW + TREE in writing situations outside of the persuasive writing instruction. The writing partners dedicated the first part of each day's lesson to brainstorming and discussing ways to transfer their learned strategies to other writing tasks. The partners also made goals of helping each other remember to use the strategies and providing assistance in using the strategies, if necessary. The pairing of higher-performing students with lower-performing students helped ensure that at least one student in the pair would be able to recognize other writing tasks in which to apply the strategy.

Third, students graphed their progress as they continued to master the use of the strategy. Students had set goals to write a good persuasive essay with all of the parts included, and graphing helped them monitor their ability to meet their goals. Students who did not meet their goals could work on adapting the strategy or changing their use of it to be more successful next time. Students who met their goals were encouraged to set new goals to improve their next persuasive essay.

Finally, Ms. Jacobson incorporated transfer tasks within her instruction to promote her students' ability flexibly to adapt the POW + TREE strategy to similar persuasive writing tasks. In addition to the transfer tasks, Ms. Jacobson worked with students to personalize their strategy use by determining the parts of the strategy that worked most effectively for them and to modify the strategy as necessary.

CONCLUSION

In our opinion, a major strength of the SRSD model is that it supports the development of a variety of executive function skills that are essential to becoming a skilled writer. For those who are interested in an additional example of how SRSD addresses executive function issues, we refer you to a previous chapter of ours, which addresses how SRSD addresses problems in executive function, attention, and memory within the context of teaching a sophisticated report-writing strategy (Graham & Harris, 1996). If you are interested in additional information on SRSD or effective writing strategies, please see Graham and Harris (2005b).

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CHAPTER 11

The Strategic Math Classroom

Executive Function Processes and Mathematics Learning

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JOAN STEINBERG

Before learning the strategies to become a successful math student, the equations and formulas were scattered in my head and did not have a place to go. Luckily, after learning to use three-column notes and other techniques, I was able to sort them into little "file cabinets" in my head.

—EMILY, NINTH GRADER (cited in Meltzer et al., 2006, p. 95)

EXECUTIVE FUNCTION PROCESSES IN TODAY'S MATH CLASSROOM

In an educational era that emphasizes problem solving and meaningful instruction, there has been a significant increase in the number of tasks that require students to plan, initiate, organize, prioritize, shift, and check their work. These executive function processes are particularly important for effective learning in the math classroom. Students need to come to class prepared, complete and pass in homework, take organized notes, study efficiently, and perform well on tests. These executive func-

tion processes generally do not come naturally to many math students, especially students with learning and attention difficulties (Brownell, Mellard, & Deshler, 1993; Bull, Johnston, & Roy, 1999; Bull & Scerif, 2001; Geary, 1990; Mazzocco & Myers, 2003; Meltzer et al., 1996, 2006; Miller & Mercer, 1997; Montague & Marger, 1997; Pressley, 1995). Further, these students often lack math skills and strategies as well as the motivation and confidence needed for success in the mathematics classroom. Providing students with systematic and strategic instruction and teaching them how to utilize accommodations effectively in the classroom are essential to enable them to navigate the math curriculum. In this chapter, we discuss the impact of executive function and dysfunction in the mathematics classroom, with a particular focus on students with learning disabilities and attention problems.

Trends in Math Teaching: From Rote Memory to Meaning

The ongoing theoretical debate between using a rote mathematics instructional model and a meaningful instructional paradigm affects students who struggle with executive function processes. Teaching styles have changed to address the new math curriculum trends, but these new styles do not necessarily accommodate those students who cannot independently generate the structures, templates, and self-regulation strategies they need to learn effectively in the math classroom (Miller & Mercer, 1997; Montague, Warger, & Morgan, 2000). In fact, a number of studies have shown that curricula and methods of instruction can have a significant impact on the math performance of students with learning disabilities and attention problems (Baroody & Hume, 1991; Carnine, 1997; Miller & Mercer, 1997).

Back in the 1960s and 1970s, when math curricula reflected a rote instructional paradigm, teachers provided math rules, algorithms, and step-by-step procedures using direct instruction. They often stood up in front of the class, lecturing and writing the steps for math problem solving on the board. They assigned worksheets for homework and, the following day, reviewed the homework with the class, problem by problem. Then they collected the homework, graded it, and wrote comments on each student's paper. The teachers developed their own tests that mimicked the skills and strategies that they taught directly in class. In these traditional math classrooms, the teachers acted as the executives, providing math instruction in a structured, systematic way within highly organized classroom environments. Therefore, it is not surprising that students were not identified as having executive function difficulties at that time.

In 2000, for the first time, the National Council of Teachers of Mathematics composed new national standards for the mathematics curriculum that embody a blend of rote and meaningful instructional approaches in math (National Council of Teachers of Mathematics, 2000). Currently, students are expected to be "reasonably computationally fluent" (Russell, 2000), and, at the same time, they must learn how to apply these computational skills to solve higher-level mathematical problems. Within a constructivist paradigm, students who have difficulties with executive function processes are more vulnerable than others to experiencing difficulty in discovering their own mathematical conjectures as well as remembering and internalizing all the steps necessary for meaningful problem solving. These students have difficulty organizing knowledge for themselves because they need scaffolds and templates to help them learn how to learn. If they struggle for too long in the math classroom, they begin to develop "learned helplessness" (Diener & Dweck, 1978) and no longer have the motivation to engage in learning mathematics. That is, they no longer have what Moran and Gardner (Chapter 2, this volume) describe as the "will" or "skill" to go up the "hill." Therefore, a major challenge facing math teachers today is how to provide an open structure for meaningful problem solving and, at the same time, the systematic, strategic scaffolds necessary for students with executive function processes who struggle to learn in the math classroom.

Meaningful Problem Solving

Math problem solving involves a four-step approach (Polya, 1957): *understanding* the problem, *organizing a plan*, *operationalizing* the plan, and *reflecting* on the product and the process. Polya's system incorporates multisensory approaches and strategies for math problem solving. The challenge for the teacher is how to make these problem-solving steps explicit for students who have difficulty with the metacognitive processes that are critical for effective problem solving (Meltzer et al., 1996, 2006; Montague et al., 2000). These students need to be taught about the underlying concepts and structures of math problems (Hutchinson, 1993; Xin, Jitendra, & Deatline-Buchman, 2005), and they need explicit "roadmaps" for the process of solving word problems from the initial conceptualization to the solution.

Mathematical *word problems* are particularly difficult for students with executive function weaknesses. When students are presented with word problems to solve, they must first read and understand what the problem is asking. They then have to make a plan and select a strategy,

such as a list, table, or chart, to help them organize and solve the problem. They must also translate the words into meaningful numbers and operations, determine the relevant information, hold words and numbers in working memory, control their impulsivity and self-monitor for accuracy and feasibility, and shift to a different strategy if they discover errors. After solving word problems, teachers require them to communicate their answers and the process they have used for problem solving and to reflect on whether or not their solutions make sense.

In general, students with executive function weaknesses, math learning difficulties, and/or attention problems often struggle with both the input and the output of new knowledge and skills. Much of their success in these areas is dependent on *how* the information is presented and how they are asked to show what they know when learning complex quantitative concepts and solving higher-level math problems. They benefit from direct, explicit math instruction on how to solve problems using rules, schemas, and strategies (Fuchs & Fuchs, 2005; Meltzer et al., 1996, 2006; Montague et al., 2000; Xin et al., 2005).

MATH STRATEGIES THAT ADDRESS EXECUTIVE FUNCTION

Though several studies have cited the effectiveness of strategy and schema-based instruction in mathematics (Harris & Graham, 1992; Montague et al., 2000; Xin et al., 2005), teachers face the challenge of how to translate theory into practice in their math classrooms. Math strategies can be taught explicitly as students follow various pathways of math problem solving from beginning to end. Incorporating math strategies and schemas into the problem-solving process utilizes a step-by-step approach and requires systematic documentation. This direct strategy instruction along with documentation helps students with executive weaknesses initially to apply strategies with teacher modeling and assistance, to internalize strategies gradually, and ultimately to use strategies independently. Though teachers can provide a menu of multisensory strategies to the entire math class, they may have to make accommodations for students with executive function weaknesses. These students need individual assistance in choosing the strategies that match their learning styles and that address specific types of math problems. Further, they need direct instruction to learn how to record the strategies in a usable form in their math strategy notebooks (Meltzer et al., 1996, 2006). The executive processes of remembering, organizing, shifting, prioritizing, and checking are all essential to higher-level math success. The following sections discuss specific strategies in each of these areas.

Memory Strategies

Memory strategies are important for automatic math fact recall, memorizing the order of operations, and remembering the overall steps in the problem-solving process. These strategies are especially critical for students with executive function difficulties, who tend to become overwhelmed by numerous details. Several studies have linked math performance with executive function skills, in particular with working memory weaknesses (Bull et al., 1999; Bull & Scerif, 2001; Geary, 1990; Miyake et al., 2000; Swanson, 1993).

Checklists, acronyms, and templates are memory strategies that are particularly helpful for students with executive function weaknesses to bypass their learning and attention problems. Examples of multisensory memory strategies are described below.

Verbal Strategies

Acronyms such as PEMDAS (see Figure 11.1) help students remember the steps in the order of operations in pre-algebra and initiate the process of math problem solving or computation. These types of verbal strategies, while helpful to all students, are essential for students with executive function weaknesses, who often do not know where to begin in terms of solving algebraic operations. Providing students with acronyms or verbal strategies such as PEMDAS helps them remember the important details and steps that can make a major difference in their performance and result in success. When students attempt to solve algebraic equations without a strategy, their answers are often wrong and result in students' confusion because of their inability to remember the order of operations.

Another example of a verbal strategy for overall math problem solving that incorporates remembering key words, operations, and steps

PEMDAS Acronym: Memory strategy for remembering the sequence of steps for simplifying algebraic equations

Parentheses
Exponents
Multiplication
Division
Addition
Subtraction

FIGURE 11.1. "Please Excuse My Dear Aunt Sally: PEMDAS."

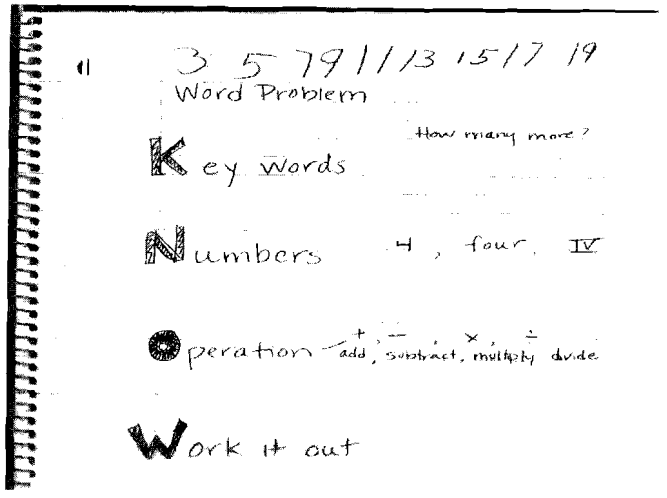

FIGURE 11.2. Example of a math roadmap: KNOW.

in problem solving is KNOW. Figure 11.2 is an example of a student's math strategy notebook page where the KNOW strategy is recorded as a means to remember the important problem-solving steps.

Memory strategies are also particularly helpful for learning math facts. Many students experience math difficulties because they cannot easily store and retrieve arithmetic facts from long-term memory (Garnett & Fleischner, 1983; Geary, Harrison, & Hoard, 2000; Jordan & Montani, 1997; Ostad, 1997). Some benefit from learning a rhyme for a particular fact, and others rely on visual or hands-on strategies. For students with executive function weaknesses, it is important both to practice the strategy and to record it in their math strategy notebooks.

Visual Strategies

Some math performance deficits are associated with deficits in visual–spatial competencies (Geary, 2004; McLean & Hitch, 1999). Combining visual strategies with verbal strategies can enhance conceptual understanding, attention, and memory. Further, when students record a rhyme in a math strategy notebook, the verbal strategy is reinforced visually, can be used for future reference, and helps them bypass long-term-memory problems.

Another example of a visual strategy is a drawing of a group of items, a cartoon, or an array for remembering math concepts and procedures, in the case of Figure 11.3, a problem that is based on multiplication and/or division. The advantage of this strategy is that math students with executive function problems can focus on *one* model, a visual representation that scaffolds across multiple content areas, from multiplication to division, fractions, decimals, percentages, and algebra. By grounding their knowledge in a mathematical array or area model, they can retrieve this one mathematical schema to help them initiate the problem-solving process.

Another visual model for multiplication is the "stoplight strategy" (Schroeder & Washington, 1989). Here, a picture of a stoplight is used for the 3x table. The red light signifies the facts $3 \times 1 = 3$, $3 \times 2 = 6$, $3 \times 3 = 9$. In a variation of the strategy developed at the Institute for Learning and Development, students are told that these facts are for younger children, who are "stopped" from doing particular activities and have more limits than older children. The yellow light facts, $3 \times 4 = 12$, $3 \times 5 = 15$, and $3 \times 6 = 18$, are the "teen facts." Teenagers have more permission than younger children but are still encouraged to slow down. Finally, the "green facts," $3 \times 7 = 21$, $3 \times 8 = 24$, and $3 \times 9 = 27$, are for adults in their 20s who have a green light and rely on their own judgment. In a graphical way, students learn to group the red facts, yellow facts, and green facts and can reduce the burden on their long-term memory by linking the fact to prerequisite knowledge relating to life experience in the form of a story and color.

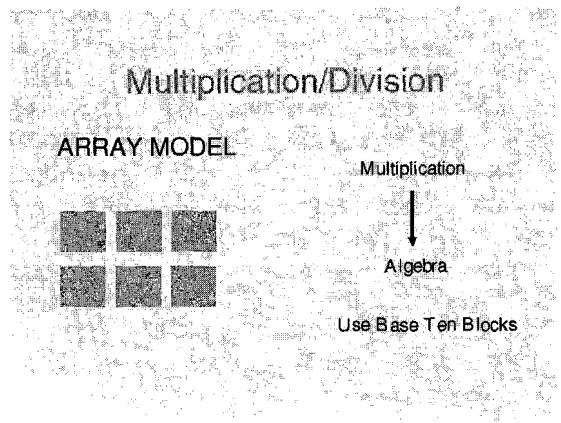

FIGURE 11.3. An array or area model, a visual representation of the multiplication problem, $2 \times 3 = 6$.

Hands-On Strategies

Many students benefit from strategies that are hands on as well as visual and verbal. One strategy for remembering 7 × 7 is both visual and hands-on. Students bend pipe cleaners, changing the two 7's into a 4 and a 9, rather than drawing the numbers or arrays in their notebooks (Schroeder & Washington, 1989). The 2 × 3 array represented in Figure 11.3 can also be taught as a hands-on strategy by having students manipulate cubes, tiles, or any discrete objects in order to represent multiplication problems in an array format.

In summary, multisensory memory strategies—verbal, visual, and hands-on—can help students with executive function difficulties and can be easily incorporated into the math classroom. One critical component is for students to document the specific strategies that they find useful in a math strategy notebook. By doing so, they compensate for weaknesses in working memory, long-term memory, and automatic retrieval, processes that are essential when solving math problems. Over time, they develop and internalize their own strategies, which become their habits of problem solving through guided practice, repetition, and consistent strategy use.

Organizing Strategies

Students with executive function difficulties often become so overwhelmed that they cannot organize the important information necessary to solve math problems. These students with weak organizational skills, math learning disabilities, and/or attention problems need roadmaps, direct strategy instruction, and guided practice to ensure effective strategy use (Miller & Mercer, 1997; Swanson, 2000). They need direct strategy instruction to help them learn how to differentiate relevant and irrelevant information so that they can organize the information enabling them to initiate the problem-solving process. They often do not know how to begin to solve a math problem, resulting in impulsive and inaccurate attempts that mislead teachers and parents into thinking that students are lazy and not trying to learn. It is not that they will not pay attention to learning but that they cannot learn in the way the information is presented; thus, their output is minimal. When they embark on their problem-solving journey to find a solution to math problems, they need roadmaps to plan and organize their route. The math strategy notebook becomes a critical tool that assists them with organizing key information and reminds them of usable math strategies that can assist in the problem-solving process.

Using Lists, Charts, and Tables

Vocabulary lists, charts, and tables recorded in a math strategy notebook assist students with executive function weaknesses to analyze and organize the language of math problems. Verbal cues in the strategy notebook help them understand what a problem is asking (see Table 11.1). Once the information is organized in this way, they can begin to shift from words to numbers, from planning to problem solving.

Roadmaps for Organizing Information for Math Problem Solving

One example of a math strategy that helps compensate for poor organizational skills is RAPS, a road map for math problem solving (Meltzer et al., 1996, 2006; see Figure 11.4).

Once the students have set their goal as solving a math problem (which in itself is a challenge for students with weak executive function) they must read the problem with understanding (*R*), so they may have to *reread and rephrase* the information. They may draw out the problem in such a way that the pictorial representation helps them in the planning phase of problem solving. Many students need to learn how to depict a problem in an *artistic* way (*A*), which helps them think about possible strategies for solving it. Some students with executive function weaknesses, learning disabilities, and attention problems, especially those who are not cognitively flexible, tend to be impulsive at this point. Working memory, along with poor attention control and the inability to inhibit irrelevant information, can also affect their math learning and problem solving (Geary, 2004). These students tend to select an approach randomly rather than think of all the possibilities and select the most relevant. They must estimate and then calculate. They have to *pre-*

TABLE 11.1. Translating Words to Mathematical Operations

Addition	Subtraction	Multiplication	Division
All together	Take away	Each has	Share
Total	Less than	The group	Dealing cards
In all	Lost	All together	Each one has?
Got more	How much left?	Getting bigger	Getting smaller
Sum	Difference	Product	Quotient

Name_____
Date_____

RAPS

R eadand Rephrase

A rt

P lan and Predict

S olve

FIGURE 11.4. Roadmap for problem solving.

dict the outcome so that they can evaluate their progress in the problem-solving process and the meaningfulness of the answer (*P*). Then they must shift once again in case the answer does not make sense. Finally, they *solve* the problem using the procedural knowledge they have learned, always mindful of the meaning behind the numbers (*S*). Thus, the RAPS roadmap is one example of a directly taught math strategy that is critical for students with executive function difficulties as it helps them focus on salient details and employ an organized approach to solving math problems.

Three-Column Note Taking

The math application of Triple Note Tote (BrainCogs; Research Institute for Learning and Development & FableVision, 2005), three-column note taking, is an extremely helpful organizing strategy. Because students with executive function weaknesses often have difficulty distinguishing relevant from irrelevant information, they feel barraged with massive amounts of detail in which they cannot find usable information (Meltzer & Krishnan, Chapter 5, this volume)

Three-column note taking (see Table 11.2) is a powerful tool if students with executive function problems are taught how to create the template, how to embed their own words into the definitions and rules, and how to use it as a study tool. Students may benefit from recording details about the use of a given strategy in their strategy notebooks (see Figure 11.5).

TABLE 11.2. Example of Three-Column Note Taking or Triple Note Tote, in a Math Strategy Notebook

Term	Definition	Example
Fraction	Part of a whole or a group	2/6, 6 pieces total *** I get 2 pieces out of 6 total or 2/6 ***
Decimal	Another way to write a fraction	2/6 = 2 divided by 6 = .33 = 33/100
Percent	Part of a hundred	33/100 means 33%
LCD (lowest common denominator)	Lowest number both denominators "go into"	LCD of 1/3 and 3/5 is 15

What is a Math Strategy Notebook: Triple Note Tote?

It is a way to keep your math facts, rules, schemas, and steps organized.
It is a way to make studying for math tests easier.

When do I use it?

- In class, when you take notes.
- At homework time, to record important concepts, vocabulary rules, and schemas.
- At study time, when you are preparing for a test or quiz.

How do I use it?

First column: Write down the math term, equation, or concept you want to know.
Second column: Read the meaning of the term but write it in your own words.
Third column: Write or draw a strategy or schema that will help you remember the information in the first two columns.
Study by reviewing all three columns.
Cover up the middle column and test yourself by looking at Column 1 and/or 3.

FIGURE 11.5. The "what, when, and how" for Triple Note Tote.

Shifting Strategies

To solve a math problem, students must shift their thinking from one numerical representation to another and, at the same time, retain the meaning of the numbers as they relate to the specific problem. Thus, students must shift flexibly from words to numbers, specifically from letters, words, and sentences in word problems to numbers, operations, algorithms, and equations. Math students with executive function weaknesses that negatively affect inhibition and working memory find it difficult to shift sets flexibly and to preserve the meaningfulness of the number representations as they problem-solve (Bull & Scerif, 2001; Miyake et al., 2000). Math instruction needs to ensure that students can switch sets while they construct, connect, decipher, and communicate their multiple representations of mathematical ideas (National Council of Teachers of Mathematics, 2000). They need to learn *when* and *how* to shift from one problem-solving strategy to another to find solutions that are accurate and make sense. Shifting strategies can emphasize real-life experiences, math talk, drawing pictures and diagrams, math-based schemas, and other representations. Below are some examples.

Shifting Representations

POSITIVE AND NEGATIVE NUMBERS

Students begin their study of integers by establishing connections with known concepts. Different concepts appeal to different learners. Some students, particularly those living in colder climates, connect to their knowledge of winter temperatures as "below zero." Others use the analogy of money, with earned money represented by positive numbers and spent or lost money represented by negative numbers. Students well versed in sports may envision a football field, where one gains and loses yards. Some students with math learning disabilities and executive function difficulties benefit from thinking about one analogy and using it consistently in order to bypass working memory difficulties and sustain focus on the relevant concept while they engage in the problem-solving process.

In addition to real-life models, many students with math difficulties benefit from the opportunity to use multiple representations to model integers. For example, some may use the traditional number line for adding and subtracting integers, others respond better to a vertical number line, and still others may want to use number chips to calculate with integers. Choosing a model and sticking with it is one way that students with executive function difficulties assume ownership of their learning and begin to approach math problems with a plan and a strategy.

RATIONAL NUMBERS

Understanding rational numbers also involves shifting representations. Students must shift from the numerical fraction or percent (e.g., 8/12, 75%) to a visual and/or conceptual image that makes sense to them. By thinking about how rational numbers relate to their experience, such as sharing brownies or chocolate bars, the concept of rational numbers comes alive. Students with weak executive function need to refer to these real-life models more frequently than their peers, and they also need strategy sheets in their math strategy notebooks that describe the step-by-step processes for computing with fractions and other rational numbers. Mnemonic strategies may help cement the steps into memory. One example of a mnemonic is using the word BIT to remind students that they need to divide the "*B*ottom *I*nto the *T*op" when changing fractions to decimals or mixed numbers.

Shifting Formats

STUDY GUIDES

In general, students with executive function weaknesses benefit from learning strategies to compensate for their inability to shift easily, and these strategies help students perform well on tests measuring their newly acquired knowledge. A shift in the format of the questions on a test or the overall layout of the test often confuses them. They may not recognize the problem type, which interferes with their ability to use the strategies they learned to solve particular types of math problems. They benefit from study guides that present math problems in the same format as the problems they will encounter on the test. Despite students' knowledge of the mathematical concepts and procedures, even subtle changes in the test format can result in numerous errors and poor grades.

PRIORITIZING STRATEGIES

Many students with math learning disabilities have difficulty prioritizing and selecting the appropriate strategies for problem solving, especially those students who struggle with executive function processes (Miller & Mercer, 1997; Steele, 2004). They become overwhelmed and often do not know where to begin. They are confused by the sequence of steps they need to follow in the problem-solving process and by the symbolism linked to solving the math problem. Since these students are often not systematic, step-by-step approaches that include visual templates and schemas that link to the mathematical concept are very effective and easy to incorporate into the classroom.

Step 1	Slope Intercept Formula	y = mx + b
Step 2	m is slope	m = ☐
Step 3	b is y intercept	b = ☐
Step 4	point of 4 intercept	(0,b) = (0,___)
Step 5		Graph

FIGURE 11.6. Template for linear equations.

Students with executive function weaknesses do not know what information is important and where to begin when they are presented with an algebraic equation to graph. Figure 11.6 is a template that helps students, especially those with executive function weaknesses, organize the steps involved in understanding and graphing the algebraic equation for a straight line, that is, $y = mx + b$.

In this schema, $y = mx + b$ represents the linear equation of a straight line. The x and the y represent points on the line, that is, (x,y) coordinates. The m represents the slope of the line, and b represents the y-intercept. $(0,b)$ is the coordinate for the y-intercept point, the point where the line intersects the y-axis. This template helps students prioritize the information and follow the procedural steps necessary to graph the line. The structure gives them a plan and a map to follow. The first step is to identify the type of figure they are graphing. They can then match the presented equation with the line or the $y = mx + b$ template. The second step is to find the m or the slope, the b or the y-intercept, and then the point $(0,b)$, the y-intercept. By using the template, they can successfully graph the line.

Drop an Anchor

Students benefit from math instruction that focuses on one major concept and set of procedures that can be applied to variations of the problem. (Carnine, 1997; Meltzer et al., 2006; Steele, 2004). For example, the linear equation template described above can be applied to any basic linear equation; then, teachers can provide scaffolds to increase the difficulty of problems systematically. Many students with executive function problems need to learn using a strategy called "A Twist at a Time," meaning they need sufficient practice at one difficulty level before the difficulty is increased and that any increase in difficulty needs to be by one step at a time (Meltzer et al., 2006). The key to initiating the task of graphing a linear equation is first to "Drop an Anchor."

Drop an Anchor is a prioritizing strategy that helps students with executive function difficulties to know what to do *first* when faced with complex problems. Students "anchor" themselves by recalling known concepts and schemas that relate to the given problem—in this case, the linear equation template. After the students read the problem, they can anchor themselves first by identifying the type of problem, then select the particular schema that represents its mathematics. Once they diagram the problem, they can take the next step of shifting from the schema to the mathematical equation that represents the problem then, solve it and check. Drop an Anchor applied to linear equations can be schema-based, as described, or formula-based. If students know they are graphing a linear equation, then they anchor themselves by writing down the formula $y = mx + b$. They write down the information that they know, such as points on the line, the slope, and the y-intercept, and figure out the solution using their prerequisite knowledge as the scaffold for problem solving. They may use a table to graph points, the slope and a point to figure out the graph, or the schema. The anchor in this case is the formula $y = mx + b$.

Another example, Distance = rate × time, can be formula-based or schema-based (see Figure 11.7). Problems can be diagrammed differently depending on the problem type (i.e., two equal distances or one distance with varying rates and time). Students who use general strategies to navigate the problem-solving process will solve it using RAPS (see Figure 11.4), but some students will also need to use a math-based schema to solve the problem systematically. Xin and colleagues (2005) offered a good example of a schema used for *proportion* (see Figure 11.8).

The Drop an Anchor strategy is particularly effective when presented with an open-response problem on a math test. Students first read over the problem, then drop an anchor in known information. For example, sup-

Distance = rate × time problem and matching schema:

If I drive from my house to school at 40 mph and it takes me half an hour to get there, how far will I drive home from school?

Drop an Anchor: D = R × T and the schema for distance to = distance back

Distance to	=	Distance back

40 × .5 = 20 miles

FIGURE 11.7. Schema for Distance = Rate × Time.

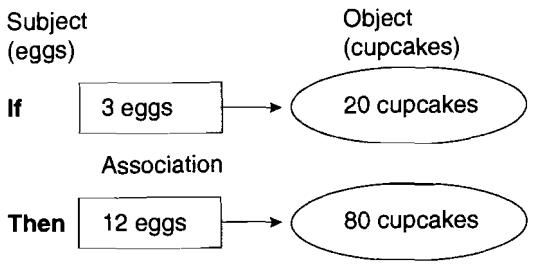

FIGURE 11.8. Schema for proportion.

pose the problem involves determining which of two cell phone plans offers the best deal. Students read over the problem, then remember similar problems that have involved algebraic equations and graphing systems of equations. Similarly, if the problem involves sale prices, students drop an anchor into the realm of percents and easily recall the process of calculating percents and subtracting to find sale prices.

Red-Flag Strategy

This is a strategy for prioritizing on a test to avoid spending too long on a difficult question. Students mark the hard question with a question mark or "red flag" and return to the red-flag questions after they have completed the rest of the test (Research Institute of Learning and Development & FableVision, 2005).

Checking Strategies

In studies that have focused on children's mathematical skills in relation to executive function, students' difficulties with inhibition and working memory often result in problems for them with shifting, monitoring, and evaluating strategies for a given task (Bull & Scerif, 2001; Miyake et al., 2000). In order to learn mathematics and perform well on math tests, students need to attend, self-monitor, self-reflect, and self-regulate, and these actions are often compromised when there is a concomitant math learning disability and/or attention problem (Gross-Tsur, Manor, & Shalev, 1996). Math strategy instruction that focuses on checking is critical for these students.

Although many of these students are eligible for the accommodation of extended time on tests, they often do not know how to make efficient use of that time, and they lack the strategies first to identify and then to self-correct their errors. It is critical to teach checking strategies to help

them focus their attention strategically to self-monitor and self-correct their errors. For these students, this level of *reflecting back* does not come easily. They need to check their answer to see if it makes sense, but they also have to reexamine their process in a systematic way. Below are some examples of checking strategies that help students with executive function difficulties. Direct strategy instruction on *how* to check their work can enhance their math performance, resulting in success and increased motivation, which lead to more positive engagement, effort, and persistence.

Error Analysis

In preparation for teaching a checking strategy, teachers must help students search for their individual patterns of test errors. Once the teacher helps students identify their most common errors, they can create a checklist or chart of typical errors together. Students then have to learn how to correct these errors.

Top Three Hits

Once the student and the teacher have identified the student's most common errors, or the teacher has alerted students to the typical errors they tend to make with a particular type of problem, a checklist of the main three error types can be created. Students are advised to write their Top Three Hits, the three errors that they typically make, on the top of their test before they begin taking it (see Figure 11.9).

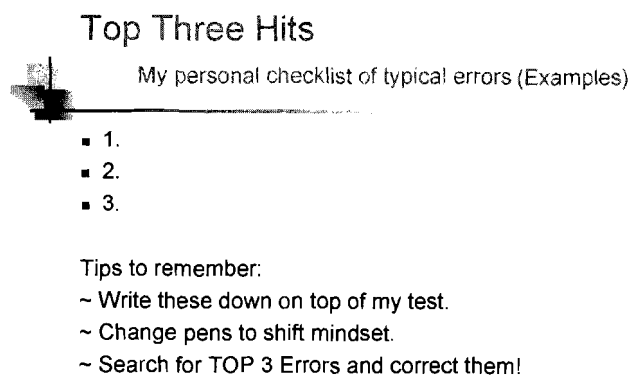

FIGURE 11.9. Example of a checking strategy: Top Three Hits.

This action often helps them catch themselves before they are about to make a typical error.

Test Taker to Test Checker

Math students with executive function weaknesses benefit from differentiating the process of test taking from the process of checking for errors. Students are encouraged initially to take the test with one color of pen or pencil. When they have completed their first attempt at taking the test, they are taught to switch pens or pencils and start the test all over again but, this time, thinking about checking for their typical errors. Some students actually write their Top Three Hits, or typical errors, on the top of the test page before they begin the checking process. They resume reviewing the test, searching for the error types that they typically make. By switching pens, they are symbolically making a cognitive shift from test taker to test checker, often resulting in more accurate solutions and higher grades that better reflect their mathematical knowledge.

THE STRATEGIC MATH CLASSROOM: CASTING A SAFETY NET FOR STUDENTS WITH WEAK EXECUTIVE FUNCTION

Creating a strategic math classroom that incorporates systematic math strategy instruction is beneficial for all students, but it is critical for students with weak executive function, math learning disabilities, and attention problems. These students need teachers who understand how executive function affects their learning and who provide strategy-based schemas, templates, checklists, scaffolds, and accommodations to help them learn *how* to learn math in the classroom. Often students with executive function weaknesses have very strong quantitative abilities that go unrecognized because they may not perform well on tests due to their problems in planning, organizing, shifting, prioritizing, and checking. They do not need a rote approach to math instruction, but they do need step-by-step approaches for meaningful math problem solving. Math strategy notebooks that are set up in an organized way for them can be the centerpiece of math strategy instruction (Meltzer et al., 2006; Roditi, 1996). Their notebooks can include strategy cards, Triple Note Totes, sample strategies and schemas that address various math curriculum areas, and strategy checklists and templates.

Teachers can encourage a strategic mindset in the classroom in several other ways. Modeling how to take notes in a math strategy notebook is an important first step. Giving the students the time needed to record steps is also critical. Structuring time for students to write down particular rules in their math strategy notebooks is essential. Grading their notebooks to make sure they are using specific strategies helps students value the importance of these strategies.

Students who value strategy use tend to improve academically (Meltzer et al., 1996, 2006; Pressley & Woloshyn, 1995; Swanson, 2001). Classroom discourse among students is helpful for encouraging them to value and share strategies that work for them. Strategies they create for themselves generate a "buzz" about strategies in the classroom. When students assimilate strategies into their repertoire, they enthusiastically share them with their peers. *Strategy shares* can be captured by the teacher on *strategy-of-the-week bulletin boards* (see Figure 11.10).

For example, a visually pleasing bulletin board can be created that incorporates multiple strategies for learning a particular math content area (i.e., five various strategies for positive and negative numbers).

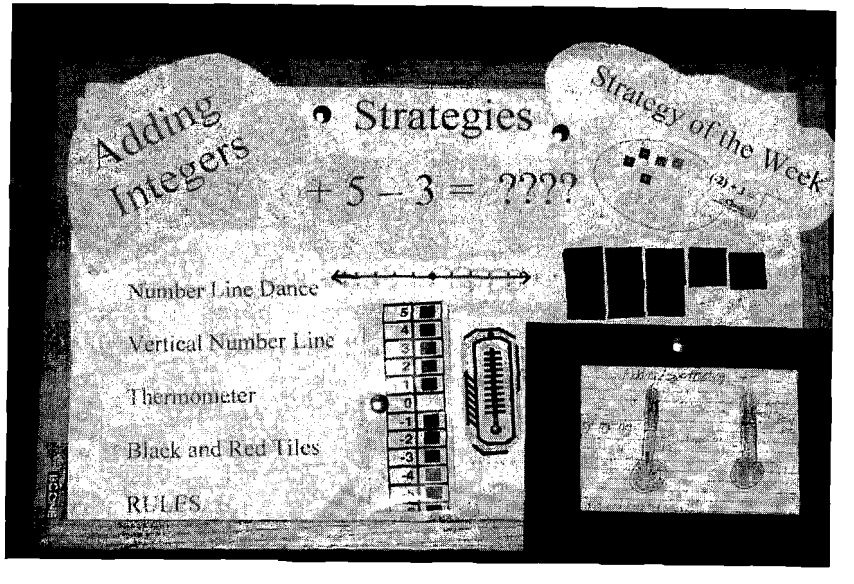

FIGURE 11.10. Math strategy bulletin board—integers.

Strategy labs can be formed in flexible groupings to help students with weak executive function learn a particular set of strategies. Some teachers have set up their own websites where they introduce strategies to help students with homework assignments and conduct strategy chats, or online strategy shares.

Many strategies and accommodations are helpful to all students in the math classroom but critical for those students whose executive function difficulties interfere with math learning and achievement. The familiar accommodations often made for students with attention problems also apply to those students with executive function weaknesses (i.e., preferential seating, extended time, and discrete ways to help them refocus their behavior). In addition, the following accommodations may also promote math learning for all students and help students with weak executive function processes to adopt a can-do attitude to keep them motivated to learn in the math classroom.

Classroom Accommodations for Students with Weak Executive Function

- Provide math-based schemas and strategies when presenting new math concepts and procedures.
- Check in frequently to make sure that students have initiated the problem-solving process and are on the right track.
- *Homework start-ups* help students begin problems and identify strategies or templates to use and ensure that they know how to complete the homework.
- Collect homework every night, grade homework and strategy notebooks, and build similar predictable routines into the classroom.
- Develop a grading system that makes the effective use of strategies count.
- Hold student–teacher conferences that help students understand why success in math is so difficult for them and identify what strategies they need to use to be successful. With teacher assistance, students can set goals and identify strategies to help them achieve these goals, then review them with the teacher at a later date.
- Use the math strategy notebook as a centerpiece for individualized strategy instruction, have notebook checks, and use these notebooks to chart progress and for discussion at parent and student conferences.

Test Accommodations for Students with Weak Executive Function

- Allow all students to reference their math strategy notebooks during test.
- Encourage students to make corrections on test that will ultimately improve their knowledge as well as give them an opportunity to raise their math grades.
- Teach students how to use checking strategies when they take advantage of extended time on tests.
- Provide study guides with math questions that mirror the format and layout of the test.
- Use multiple modes to evaluate students' knowledge, including teacher-made tests; fill-in-the-blank, open-response, and matching questions; projects, board demos, and verbal discussion; notebook checks, homework, strategy use, and test corrections.

CONCLUSION

Teaching strategies directly, utilizing math-based schemas, and providing accommodations in a highly structured but engaging way can provide the scaffolds that students with weak executive function, math learning disabilities, and attention problems desperately need in order to learn mathematics. By doing so, math teachers can change their students' self-perceptions. Math students with executive function difficulties no longer perceive themselves as dumb or incapable of learning math, but are empowered with a can-do attitude. Perhaps a brilliant mathematical mind will be discovered in your strategic math classroom, and that same math student who struggles with EF today will be a leading "business executive" tomorrow.

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CHAPTER 12

Teaching Metacognitive Strategies That Address Executive Function Processes within a Schoolwide Curriculum

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MICHAEL PRESSLEY

During the 30 years since educators were introduced to John Flavell's (1977) and Ann Brown's (1978) early formulations of metacognition, instruction in how to take charge of and monitor thinking has played an increasingly prominent role in how teachers work with students, especially struggling readers. Over the years, educators' conceptualization of metacognition has continued to evolve through the lenses of contemporary scholars who have applied and expanded notions of metacognition to teaching executive function processes (e.g., setting goals, applying strategies, and initiating behavior) in many aspects of the elementary and middle school curricula (see Israel, Block, Bauserman, & Kinnucan-Welsch, 2005; Zimmerman & Schunk, 2001). In this chapter, we describe the goals and instructional approach we believe should be part of an upper elementary and middle school, across-the-curriculum program to develop metacognitive strategies and enhance executive processes. Although the goals and instruction we describe are good instruction for all students, they are particularly important for at-risk students, who tend not to discover these strategies and processes on their own.