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# William M. Cruickshank Memorial Lecture Delivered at the 2008 Conference of the International Academy for Research in Learning Disabilities

## Executive Function and Metacognition in Students with Learning Disabilities: New Approaches to Assessment and Intervention[5]

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Abstract

Success in our 21st century schools is linked with students' mastery of a wide range of academic and technological skills that rely heavily on executive function processes. This article describes a theoretical paradigm for understanding, assessing, and teaching that emphasizes the central importance of six executive function processes: goal setting, cognitive flexibility/shifting, organizing, prioritizing, accessing working memory, and self-monitoring (Meltzer, 2007, 2010, 2013a). For each of these core processes, there is an emphasis on the effects of executive function on learning as well as some of the challenges experienced by students with learning disabilities. There is also a focus on the interactions among executive function processes, self-awareness, effort, and persistence as well as the major principles of intervention and treatment.

[5] This article is based on the William Cruickshank Memorial Lecture presented in Toronto, Canada at the 32nd Annual Meeting of the International Academy for Research in Learning Disabilities, June, 2008.

*"Mike's performance has been unpredictable all year! He has many creative ideas and he participates actively in classes. However, he is usually late with written papers and projects and he does not seem to care about his homework. His test grades fluctuate from the 90s to the 60s. His other teachers have told me that they think he is lazy. I think that Mike may have a problem."* (8th grade teacher)

Success in our 21st century schools is linked with students' mastery of a wide range of academic and technological skills which rely heavily on executive function processes. Beginning in the early grades, students are increasingly required to take greater responsibility for their own learning by organizing and integrating a large amount of information that is rapidly changing. They are also expected to become proficient at note-taking, studying, and test-taking, all tasks that depend on students' cognitive flexibility and their ability to prioritize information. Furthermore, students' academic success depends on their ability to plan their time, organize and prioritize materials and information, think flexibly, mentally juggle information, and monitor their own progress. Therefore, it is important to help students, particularly students with learning disabilities (LD), to understand *how* they learn and to teach them specific strategies that address these executive function processes.

For the purposes of this paper, "executive function" is used as an umbrella term that is broader than metacognition and incorporates a range of interrelated processes responsible for goal-directed behavior (Anderson, 2002; Anderson, Jacobs, & Anderson, 2008; Eslinger, 1996; Gioia, Isquith, Guy, & Kenworthy, 2001; Meltzer, 2013). More specifically, the term, "executive function" refers to a wide range of cognitive processes that are controlled by the prefrontal cortex (Eslinger, 1996). These comprise:

- Metacognitive knowledge about tasks and strategies
- Flexible use of strategies
- Attention and memory systems that guide these processes (e.g. working memory)
- Self-regulatory processes such as self-monitoring

The work summarized here is built on the seminal research of Flavell on goal-oriented problem-solving (Flavel, Friedrichs, & Hoyt, 1970) and the studies of Brown and Campione (Brown, Bransford, Ferrara, & Campione,1983; Brown & Campione,1986) on metacognition and self-regulation, as well as the more recent models of executive function (Barkley, 1997; Bernstein & Waber, 2007; Denckla, 2005, 2007; Gioia, Isquith, Guy, Kenworthy, & Barton, 2002).

In this paper, based on my Cruickshank Memorial Lecture, I describe a theoretical paradigm for understanding, assessing, and teaching that emphasizes the central importance of six executive function processes: goal setting, cognitive flexibility/shifting, organizing, prioritizing, accessing working memory, and self-monitoring (Meltzer, 2007, 2010, 2013a). For each of these core executive function areas, I discuss the effects of executive function on the learning process and describe some of the challenges experienced by students with learning difficulties. I focus on the interactions among executive function processes, self-awareness, effort, and persistence as well as the major principles of intervention and treatment.

## Executive Function Processes and Academic Performance

> *"When I have to write a paper, I sit down at my computer but my mind feels like it's stuck. I try to write but I can't figure how to get my mind unstuck. I grab at an idea and write a sentence. I get so frustrated when I have written only a few sentences after an hour, so I give up."* (John, 15 years, 9th grade)

Students with executive function weaknesses often have difficulty coordinating and integrating the different subskills involved in many academic tasks such as writing, summarizing information, executing and completing projects in a timely manner, and studying for tests (Meltzer, 2010; Meltzer & Basho, 2010). These students often have difficulty organizing and prioritizing information and they struggle when they are required to shift flexibly in order to utilize alternate approaches. Working memory and self-monitoring weaknesses also make it difficult for these students to mentally juggle information, self-monitor, and self-check. As a result, they overfocus on details, while ignoring the major themes and feel as if their brains become "clogged" with information as they struggle to produce. The paradigm that has guided our work on executive function is based on the analogy of a "clogged funnel," as illustrated in Figure 1 (Meltzer, 2004, 2007, 2010, 2013a; Meltzer & Krishnan, 2007). Because these students cannot shift flexibly among alternative approaches to "unclog" the funnel, their written work, study skills and test performance are compromised, and their academic grades do not reflect their strong intellectual ability.

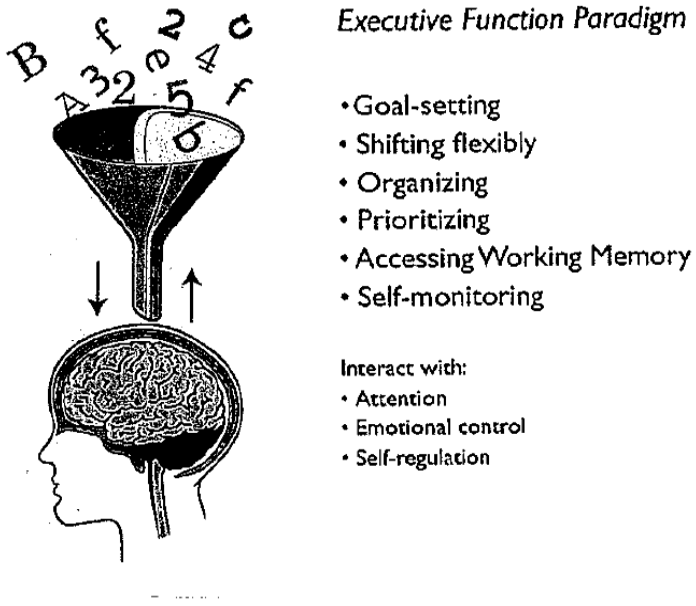


*Figure 1.* Executive Function Paradigm, adapted from Meltzer (2004), Copyright 2007 by the Guilford Press, Reprinted by permission.

**Table 1.** Executive Function Processes Required for Academic Performance

Prioritizing

- Planning and allocating time to the many steps involved in different assignments (e.g., writing papers, taking notes for history or science, or completing long-term projects).
- Prioritizing by allocating more time and effort to major projects and tests.
- Figuring out which details are critical and which details can be ignored when reading, taking notes, or writing essays.
- Estimating how much time to spend on reading and research versus output (e.g., writing a paper, editing, and layout).

Organizing

- Organizing ideas, such as summarizing key ideas on strategy cards rather than rereading the text over and over.
- Organizing materials such as class notes, textbooks, and study guides.
- Organizing workspace (e.g., reducing distractions and clutter).

Shifting

- Shifting flexibly from the major themes to the relevant details to meet the demands of the reading, writing, or studying task.
- Using outlines such as graphic organizers or linear outlines to get "unstuck" when writing papers or projects.
- Shifting between operations and between words and numbers for math computation or word problems.

Accessing Working Memory

- Studying strategically so that students connect concepts and can "juggle information mentally" in order to access this information on a long-term basis.
- Remembering to hand in completed assignments on time.
- Remembering to bring necessary books and materials from school to home and back again.

Self-monitoring/ Checking

- Reviewing papers and tests to identify frequent error pattern
- Developing personalized error checklists to correct errors when writing papers, taking tests or completing homework
- Checking and correcting "careless errors" when writing papers, taking tests, or doing homework.

Adapted from Meltzer (2010). Copyright, The Guilford Press. Reprinted by permission.

These difficulties become more evident during middle and high school due to the larger volume and complexity of the workload as well as the increasingly demanding curriculum (see Table 1). As a result, these students struggle to perform at the level of their intellectual potential, which can be extremely frustrating and often affects their motivation as well as their academic performance.

**Executive Function Strategies, Self-Concept, and Effort:**
**The Foundation of Academic Success**

Our research has shown that motivation, self-understanding, and academic self-concept are connected cyclically with students' use of executive function strategies as well as their effort and persistence (Meltzer, Katzir, Miller, Reddy, & Roditi, 2004; Meltzer & Krishnan, 2007) (see Figure 2). These cognitive and motivational processes are the underpinning of academic success for all students (Brunstein, Schultheiss, & Grässman, 1998; Helliwell, 2003; Kasser & Ryan, 1996; Meltzer, Reddy, Pollica, & Roditi, 2004; Pajares & Schunk, 2001; Sheldon & Elliot, 1999).

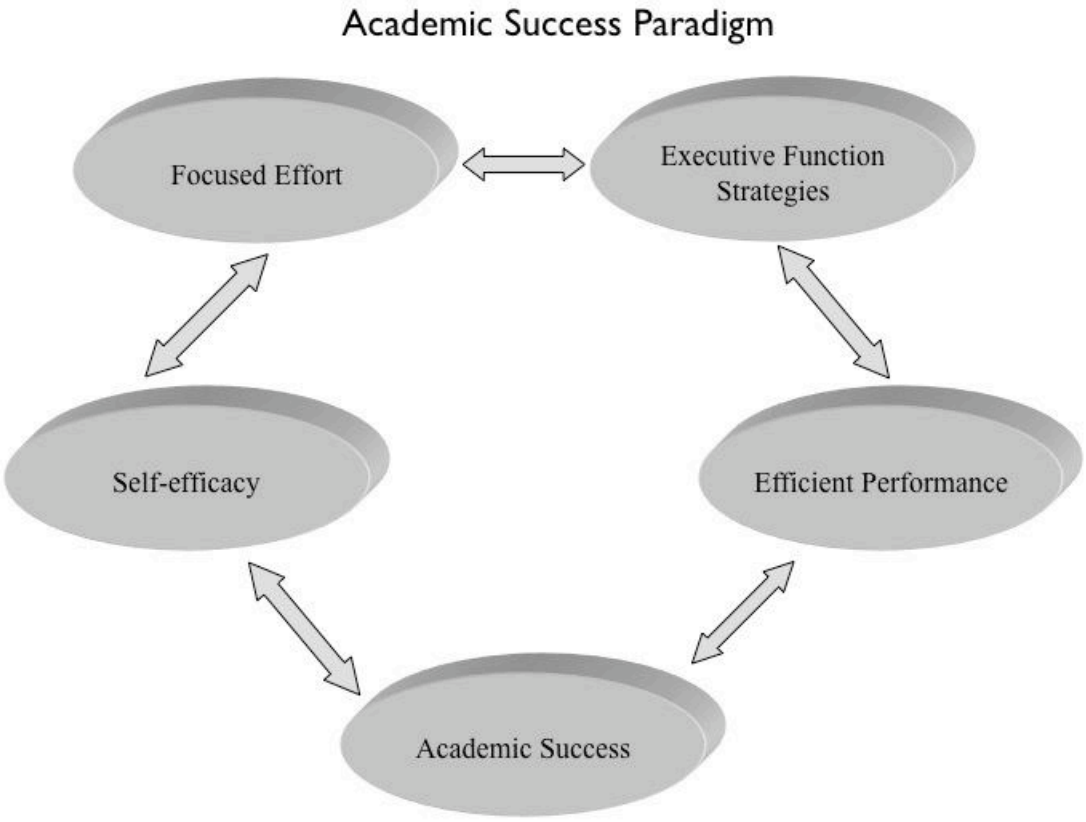


*Figure 2.* Academic Success Cycle

Adapted From: Meltzer, L J., Reddy, R., Pollica, L., & Roditi, R. (2004). Copyright 2004 by the International Academy for Research in Learning Disabilities. Reprinted by permission.

Therefore, executive function strategies are critically important for improving academic performance. As is evident from Figure 2, students' use of executive function strategies often increases their efficiency as well as their accuracy, and they begin to improve academically. Academic success, in turn, boosts students' self-confidence and self-efficacy so that their effort is more focused on achieving their personal goals. Consequently, a cycle of success is promoted when students focus their effort on applying executive function strategies to their schoolwork (Meltzer, 2010; Meltzer, Katzi et al. 2004; Meltzer, Reddy, Pollica et al., 2004, Meltzer, Reddy, Sales et al., 2004). Students therefore need to understand their own learning profiles and which strategies work well for them, as well as why, where, when and how to use specific strategies. This ability to think about their own thinking and learning, referred to as metacognitive awareness (Flavell, 1979), is strongly associated with students' motivation, effort, and willingness to use executive function strategies in their schoolwork.

Executive function strategies can provide a lifeline to academic success for all students as they learn how to set realistic goals, focus their effort on achieving these goals, and self-regulate their cognitive, attentional and emotional processes (see Figure 3). Furthermore, when students begin to improve academically as a result of using these executive function strategies, they are more motivated to work hard and to persist despite their difficulties, which builds resilience and academic success (Meltzer, 2010; Meltzer, Reddy, Brach, Kurkul, & Basho, 2011; Meltzer, Reddy, Brach, Kurkul, Stacey et al., 2011).

## Assessment of Executive Function

> *"Jamie is a very bright student whose grades are inconsistent. He does well on quizzes and short tests but he often does not hand in his homework. I wish I knew how to help him."* (8th grade teacher)

Informal assessment methods can help us to understand students' use of executive function processes and to pinpoint *why* and *how* particular students may be struggling. It is then possible to intervene by introducing specific instructional approaches, assessing students' progress, and modifying instruction. This continuous cycle that links assessment and teaching allows instructional methods to be adjusted to the changing needs of students. Many of these principles are incorporated in the Response to Intervention (RTI) approach that is now used more widely in U.S. schools to improve early identification of reading and learning difficulties (Fuchs & Fuchs, 1991; Kame'enui, 2007).

Currently, there are very few measures available for assessing students' use of executive function strategies. The most widely-used and reliable questionnaire system is the *Behavior Rating Inventory for Executive Function* (BRIEF; Gioia et al., 2001; Gioia et al., 2002). The BRIEF comprises a parent questionnaire, a teacher questionnaire, and a self-rating form for students from 5 years old into adulthood. The 86 items assess behaviors associated with the most important executive function processes, e.g.: *"Forgets to hand in*

*homework, even when completed; Gets caught up in details and misses the big picture; Becomes overwhelmed by large assignments; Underestimates the time needed to finish tasks"* (Gioia, Isquith, Guy, & Kenworthy, 2001).

Another criterion-referenced assessment system that compares students', teachers', and parents' perceptions of students' metacognitive awareness and strategy use, is the Metacognitive Awareness System or MetaCOG (Meltzer, 2010; Meltzer, Reddy, Pollica et al., 2004; Meltzer & Krishnan, 2007; Miller, Meltzer, Katzir-Cohen, & Houser, 2001). The MetaCOG, for use with 9-18 year olds, comprises five rating scales that allow educators to compare their own judgments with their students' self-ratings of their effort, strategy use, and academic performance (see Table 2).

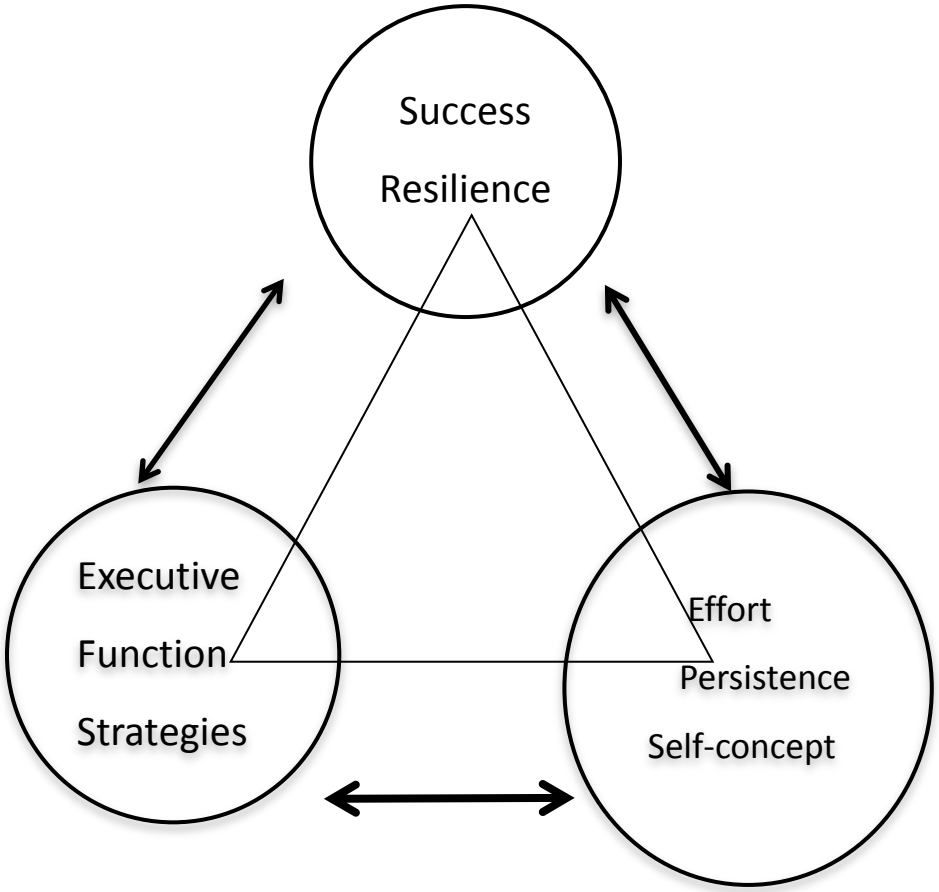


*Figure 3.* Academic Success Paradigm. From Meltzer (2010); Meltzer, Reddy, Brach, Kurkul, & Basho (2011).

Table 2.

*Metacognitive Awareness Survey System (MetaCOG)*

STUDENT Questionnaires

- ME – Motivation and Effort Survey
- STRATUS – Strategy Use Survey
- MAQ – Metacognitive Awareness Questionnaire

TEACHER Questionnaires

- TPSE – Teacher Perceptions of Student Effort
- TIQ – Teacher Information Questionnaire

*5-point rating for all surveys*

Ratings focus on students' performance in selected academic domains that depend on executive function processes, namely, written language, homework, studying, and taking tests (see Tables 2a & 2b; Meltzer, Katzir-Cohen, Miller, & Roditi, 2001; Miller et al., 2001). Completion of the MetaCOG surveys helps students and teachers to better understand students' individual learning profiles, which provide baseline information for improving students' metacognitive awareness and teaching them to use executive function strategies.

Table 3a.

*MetaCOG Sample Items: Students' vs Teachers' Ratings of their Performance on Academic Tasks that involve Executive Function Processes*

| **ME –Students** | **TPSE-Teachers** |
|---|---|
| ***Please judge how well you do on:*** | ***Please judge how well this student does on:*** |
| • Organization | • Organization |
| • Long-term projects | • Long-term projects |
| • Making a plan before starting work | • Making a plan before starting work |
| • Using strategies in my schoolwork | • Using strategies in his/her schoolwork |
| • Checking my work | • Checking his/her work |
| • Homework | • Homework |
| • Tests | • Tests |
| • Long-term projects | • Long-term projects |

Systems such as the MetaCOG can be used for different purposes over the course of the school year: (a) To understand students' views of their own effort, use of strategies, and

academic performance; (b) To help educators and clinicians to compare their own judgments with their students' self-perceptions; (c) To develop a system for teaching strategies that help students to become strategic learners who plan, organize, prioritize, shift flexibly, memorize, and check their work; (d) To track students' understanding and implementation of these strategies over time.

Table 3b.

*MetaCOG Sample Items: Students' vs Teachers' Ratings of their Motivation and Effort on Academic Tasks that involve Executive Function Processes*

| **ME –Students** | **TPSE-Teachers** |
|---|---|
| • Doing well in school is important to me. | • Doing well in school is important to this student. |
| • I spend as much time as I need to get my work done. | • S/he is a hard worker. |
| • I keep working even when the work is difficult. | • S/he doesn't give up even when work is difficult. |
| ***I work hard on:*** | ***Please judge how hard this student works*** |
| • Homework | • Homework |
| • Long-term projects | • Long-term projects |
| • Studying for tests | • Studying for tests |
| • Other activities (sports, music, art, hobbies) | • Other activities (sports, music, art, hobbies) |

**Note:** The ME and TPSE each comprise 36 items using a 1-5 rating scale.

**MetaCOG Student Surveys**

**Motivation and Effort Survey (ME)** (Meltzer, Katzir et al., 2004; Meltzer, Reddy, Pollica et al, 2004; Meltzer, Reddy, Sales et al., 2004). The ME consists of 38 items that assess students' self-ratings of their effort and performance on different academic tasks that

depend on executive function processes (alpha =.91[see Tables 3a & 3b], Meltzer, Sayer, Sales, Theokas, & Roditi, 2002). Students rate themselves on a 1-5 scale (from never to always) in terms of how hard they work and how well they do in selected academic areas such as reading, writing, math, homework, studying for tests, and long-term projects (e.g., *I spend as much time as I need to get my work done; I finish my work even when it is boring; I do schoolwork before other things that are more fun*). Students are also asked to describe themselves as learners.

**Strategy Use Survey (STRATUS)** (Meltzer, Katzir et al., 2004; Meltzer, Reddy, Pollica et al, 2004; Meltzer, Reddy, Sales et al., 2004). The STRATUS consists of 40 items that assess students' self-reported strategy use in reading, writing, spelling, math, studying and test-taking (alpha = .945). Items focus on students' perceptions of their use of strategies for planning, organizing, remembering, and self-checking (e.g., *When I have to remember new things in school, I make up acronyms to help me; Before I write, I plan out my ideas in some way that works for me (outline, list, map); When I do math, I ask if my answers make sense*.)

**Metacognitive Awareness Questionnaire (MAQ)** (Meltzer, Katzir et al., 2004; Meltzer, Reddy, Pollica et al, 2004; Meltzer, Reddy, Sales et al., 2004). The MAQ consists of 18 items that assess students' understanding of what strategies are and how they can apply strategies to their schoolwork (e.g., *When you begin something new, do you try to connect it to something you already know?; When you begin something new, do you try to think about how long it will take and make sure you have enough time?*).

**MetaCOG Teacher Surveys**

**Teacher Perceptions of Student Effort** (TPSE; Meltzer, Katzir et al., 2004; Meltzer, Reddy, Pollica et al, 2004; Meltzer, Reddy, Sales et al., 2004). The TPSE is the teacher version of the ME and consists of 38 items that assess teachers' ratings of students' effort in different academic domains (alpha = .980; see Tables 3a & 3b). Teachers rate students' effort and performance in reading, writing, math, homework, tests, and long-term projects, all academic tasks that rely on executive function processes (e.g., *He spends as much time as needed to get his work done; She does not give up even when the work is difficult*.) Teachers also rate students' overall strategy use and academic performance in response to the question: "If you had to assign a grade for this student's overall academic performance, what would this be?"

**MetaCOG Parent Surveys**

**Parent Perceptions of Student Effort (PPSE)**. The PPSE consists of 38 items that assess parents' ratings of students' strategies and the effort they apply in different academic domains that require the use of executive function processes. Items are identical to those used on the student self-report survey (ME), and the teacher survey (TPSE).

As was discussed, student, teacher, and parent reports can be directly compared to

determine the overall consistency in their ratings of many of the core components of executive function processes across different settings (see Tables 2a and 2b). However, it must be kept in mind that students' perceptions of their own effort and strategy use are often very different from their parents' and teachers' perceptions, as has been shown in a number of studies (Meltzer, Katzir et al., 2004; Meltzer, Reddy, Pollica et al, 2004; Meltzer, Reddy, Sales et al., 2004; Stone & May, 2002).

In summary, survey systems that raise teachers' and clinicians' awareness and understanding of students' effort, and use of executive function strategies, can improve their understanding of why and how students may be struggling. These systems can also help teachers to implement and monitor the effectiveness of specific instructional strategies, as will be detailed next.

## Strategies that Address Executive Function Processes

Intervention research has shown that explicit and highly structured metacognitive instruction benefits all students and is essential for the academic progress of students with learning and attention difficulties (Deshler, Ellis, & Lenz, 1996; Deshler & Schumaker, 1988; Meltzer Katzir et al.; Paris, 1986; Pearson & Dole, 1987; Rosenshine, 1997; Swanson, 2001; Swanson & Hoskyn, 1998, 2001). Comparisons of different interventions highlight several important principles of this instruction:

- Strategies should be taught explicitly and systematically, using scaffolding and modeling, and providing time for practice (Pressley, Goodchild, Fleet, Zajchowski, & Evans, 1989; Swanson, 1999, 2001; Swanson & Hoskyn, 1998).
- Strategy instruction should be embedded in the curriculum (Deshler & Shumaker, 1986; Deshler, Warner, Schumaker, & Alley, 1983, 1996; Ellis, 1993, 1994).
- Students should be exposed to activities that help them to understand their strengths and weaknesses so that they can select strategies that match their learning profiles and learn how to generalize these strategies to different content areas (Meltzer, 1996; Meltzer, Roditi, Houser, & Perlman, 1998).
- Metacognitive awareness and effective strategy use are promoted when teachers provide systematic and explicit instruction focused on executive function strategies (see Table 1) and when they include strategy use in their grading systems.

One example of an easily implementable classroom system is to teach students to complete strategy reflection sheets that require them to think about and to write down the strategy they have used to approach their homework or to study for tests. These strategy reflection sheets are designed to promote metacognitive awareness, encourage students to use strategies systematically, and remind them to check and edit their work (see Figures 4a and 4b). When grades for homework and tests include points for completing these strategy reflection sheets, teachers promote strategic habits of mind and students are more likely to make the effort needed to use these strategies consistently. In other words, metacognitive awareness and effective strategy use are promoted when teachers make strategy use count in the classroom.

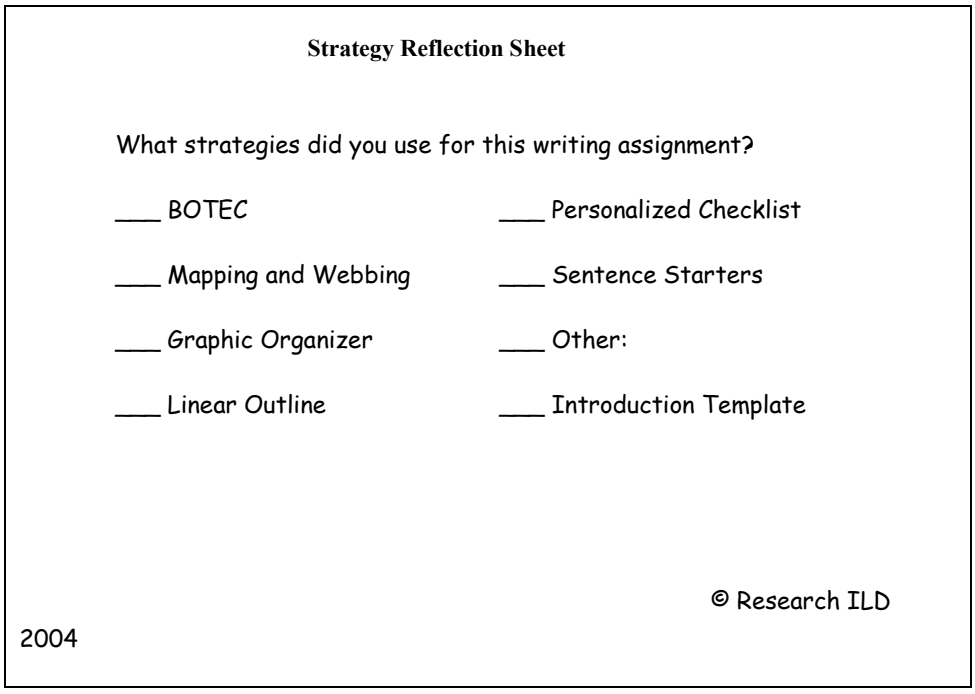


*Figure 4a.* Strategy reflection sheet for writing: Structured questions that scaffold the writing process.

The following sections focus on each of the key executive function processes, namely, setting goals, shifting flexibly/cognitive flexibility, organizing and prioritizing, accessing working memory and self-monitoring/self-checking. Strategies for addressing these processes are summarized briefly as well.

**Goal-Setting**

Goal-setting refers to the ability to set specific, realistic objectives that can be achieved within a defined period of time. Goal-setting also involves the selection of goal-relevant activities, predicting and planning for obstacles, effective and efficient strategy use, focused effort, and persistence. Goal-setting and planning help students to understand the task's objectives, identify the steps involved in accomplishing the task, and organize the time and resources needed to complete the task. When students set their own goals, they show greater commitment and are more motivated to attain these goals (Schunk, 2001; Winne, 1996, 2001; Zimmerman, 2000; Zimmerman & Schunk, 2001). Goal-setting also enhances self-efficacy, achievement, and motivation (Schunk, 2001). Krishnan, Feller and Orkin (2010) emphasize that goal-setting requires students to:

- Understand their learning strengths and weaknesses
- Understand the 'big picture' and envision the end point of a task
- Value the task
- Learn to set goals that are attainable

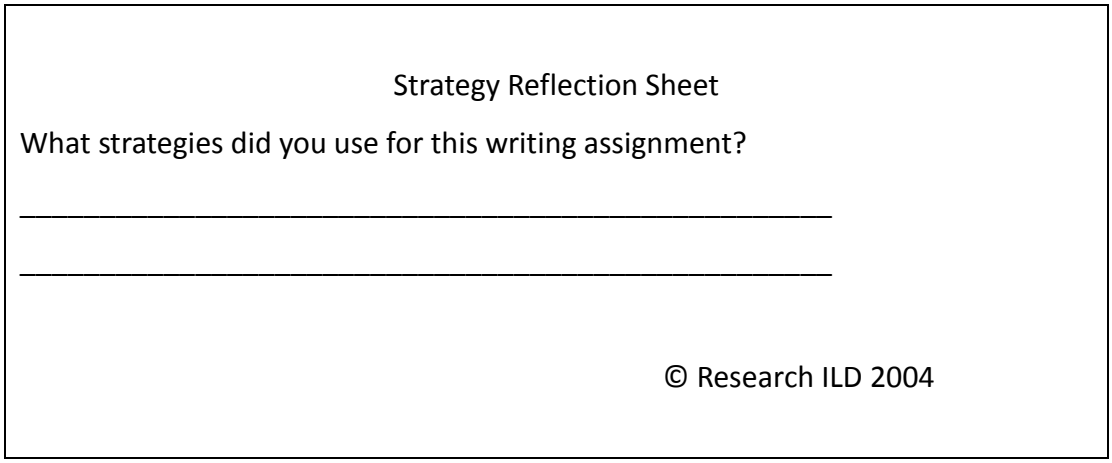


*Figure 4b.* Strategy reflection sheet for writing: Open-ended questions

Students who are able to set goals and shift from broad concepts and major themes to relevant details and back again (Meltzer, 2007), are usually more successful with the complex tasks that are typical in our 21st century schools. In contrast, students with poor self-understanding of their learning profiles often fail to set realistic short-term and long-term goals. This lack of direction often compromises their academic performance (Krishnan et al., 2010; Stone & Conca, 1993; Swanson, 1989; Torgesen, 1977).

Goal-setting and time management strategies are critically important for promoting independent learning (Hughes, Ruhl, Schumaker, & Deshler, 2002; Krishnan et al., 2010; Sah & Borland, 1989). Beginning in the early grades, students can be taught effective goal-setting and time estimation strategies. These strategies help students to build goal-oriented schedules by planning their schedules and estimating their work time for less structured homework time. Weekly and monthly calendars help to impose structure and build self-monitoring strategies so students can track deadlines for long-term projects, pace themselves when completing assignments, and monitor the accuracy of their time estimates. Strategies for juggling the amount of time assigned to homework, long-term projects, studying, and after-school activities are increasingly important as students advance through the grades. From the early grades, students also need to learn how to analyze the goals of their assignments and to plan their approach to long-term projects and papers. In the higher grades, students benefit from strategies for breaking down tasks into manageable parts so they can juggle multiple deadlines for many different ongoing assignments and projects.

**Cognitive Flexibility/ Shifting**

Cognitive flexibility, or the ability to think flexibly and to shift approaches, is probably the most important executive function process, and is often a major weakness in students with learning and attention difficulties (Meltzer, 1993; Meltzer

& Krishnan, 2007; Meltzer & Montague, 2001; Meltzer, Solomon, Fenton, & Levine, 1989). The ability to shift problem-solving approaches, to integrate different representations, and to adapt to unexpected situations develops across the lifespan and varies across individuals (Brown, 1997; Cartwright, 2008a, b, c; Deák, 2008; Dweck, 2008; Elliott & Dweck, 2005). Developmental changes from childhood into adulthood influence children's ability to manage the cognitive complexity of academic tasks and to process information from multiple sources simultaneously (Andrews & Halford, 2002; Cartwright, 2008a, b; Zelazo & Műller, 2002). In the elementary grades, students' understanding of the importance of using a range of different approaches is more limited than it is for middle and high school students. In the higher grades, students' ability to learn new concepts is often associated with their willingness to shift approaches flexibly and to abandon previously successful techniques (Cartwright, 2008a, b). Students' motivation, interest, passion, and emotional mindsets also influence their willingness to try different approaches and to shift flexibly from one approach to another, rather than continuing to rely on the same approach to tasks (Alexander, 1998; Paris, Lipson, & Wixson, 1983; Shanahan & Shanahan, 2008).

This ability to shift approaches and to synthesize information in novel ways is essential for effective reading, writing, math problem solving, note-taking, studying and test-taking. More specifically, accurate and efficient reading decoding requires students to flexibly coordinate the letter-sound relationships with the meanings of printed words (Cartwright, 2008a, b, c). In other words, students need to recognize the importance of what Gaskins (2008) refers to as "crisscrossing the landscape" in order to select decoding approaches that fit the text. Reading comprehension requires students to recognize the purpose or goal of reading, process the meaning of text, flexibly access their background knowledge (Cartwright, 2008a, b, c), and monitor their comprehension (Block & Pressley, 2002; Pressley & Afflerbach, 1995). Reading for meaning also taxes students' ability to flexibly manage many different types of linguistic information at the word-level, sentence level, and paragraph level (Brown & Deavers, 1999; Goswami, Ziegler, Dalton, & Schneider, 2001, 2003). More specifically, students must shift between the major themes and relevant details, between the concrete and the abstract, and between literal and symbolic meanings. Similarly, when writing, students need to shift between the important concepts and supporting information and they also need to separate their own perspective from that of the reader. In the math domain, students' understanding of concepts, computational procedures, and word problems depends on their cognitive flexibility. Students are required to shift from the words and sentences in math problems to the numbers, operations, algorithms and equations needed to solve the problems (Roditi & Steinberg, 2007). They also need to learn how and when to shift problem-solving schemas so their final calculations are accurate and logical (Montague & Jitendra, 2006). In content area subjects, including science and history, students are required to read texts where they need to differentiate main ideas from details.

Furthermore, many words and phrases have multiple meanings, and students' understanding of these texts depends on their use of context clues to shift flexibly among different possible meanings. Similarly, learning a foreign language requires a significant amount of flexible thinking, as students are challenged to shift back and forth between their native language and the language they are learning. Finally, studying and test-taking require students to shift among different topics and problem types as they are often presented with information that is formatted differently from the way in which they learned.

For students who struggle to shift flexibly between perspectives and to process multiple representations easily, academic tasks often become progressively more challenging as they advance beyond the first few grades in school. Furthermore, these students experience mounting difficulty as the curriculum demands increase in complexity and require them to interpret information in more than one way, change their approach when needed, and choose a new strategy when the first one is not working (Westman & Kamoo, 1990). Therefore, students need a variety of opportunities to practice shifting problem-solving approaches, to think flexibly, and to use their knowledge in different ways (Bereiter & Scardamalia, 1993; Dweck, 2008). When teaching emphasizes problem-solving and critical thinking, students are required to think flexibly about ways in which their solutions could lead to different possible outcomes (Sternberg, 2005). Furthermore, when teaching encourages peer discussion and collaborative learning, students are exposed to multiple viewpoints (Yuill, 2007; Yuill & Bradwell, 1998) and can be challenged to approach problems from the perspectives of their peers. Therefore, classrooms and schools that teach students to think flexibly and to solve problems from different perspectives across the grades and content areas lay the foundation for life-long success in their students.

**Organizing and Prioritizing**

*"The way my mind works with that liquefied gobble of dots, my notes would look scattered on a page. One of the most useful strategies I learned was multi-column notes. With this system, I learned to make a hierarchy of notes and…. to use this structure to relate my ideas. This structure helped me to study and to write long papers." (Brandon, college graduate)*

Organizing and prioritizing are important executive function processes that underlie most academic and life tasks. These processes affect performance from the earliest years and have a stronger influence in the higher grades when students are required to organize a large volume of materials and information. Reading and note-taking, studying for tests, and completing writing assignments all require students to impose their own structure on the information presented to them. How easily students learn and remember information depends on the ease with which they use strategies to organize and prioritize concepts and details, so that working memory is less cluttered (Hughes, 1996). While many students successfully participate in classes and accurately complete structured homework

assignments, they often have more difficulty with independent, open-ended tasks which require them to organize and prioritize information and ideas.

Students therefore need to learn strategies for systematically organizing and prioritizing their time, their materials, and their ideas. They also need to learn how to apply these strategies to their reading, writing, note-taking, studying, and test preparation. Instruction that includes organizational strategies should be explicit, systematic, and incorporated in the curriculum across the grades (Krishnan et al., 2010). In fact, teachers in the elementary grades usually create structured systems in their classrooms that help students to organize the materials in their desks, bookbags, and lockers. However, many students do not internalize these processes and they need additional activities that promote metacognitive awareness and self-understanding. Furthermore, students need activities that help them to understand their own learning profiles as well as the specific organizational strategies that they find helpful. As students advance to the higher grades, they are often expected to use planners, assignment books, binders, and notebooks independently; teachers need to build time into the daily school schedule to ensure that students are using these systems systematically. This structure remains important at the high school level when many students, especially students with learning and attention difficulties, still need explicit systems and strategies for organizing and prioritizing their homework, long-term assignments, and study time. When organizational strategies are taught systematically in the context of school assignments at all grade-levels, students become metacognitive learners who internalize these strategies and are more likely to succeed academically (Krishnan et al., 2010). Success, in turn, increases students' motivation to use these strategies independently and to generalize across different content areas and contexts (Meltzer, 1996, 2010; Swanson, 1999).

Strategies for organizing and prioritizing information underlie efficient reading comprehension, written language, note-taking, and studying. Templates, thinking maps, and graphic organizers provide a structured format for helping students to read for meaning, extract major themes, and relate new with known information (Kim, Vaughn, Wanzek, & Shangjin, 2004). Graphic organizers are also effective for improving students' reading comprehension, note-taking, and written language across a wide range of subject areas including language arts, science, and social studies (Bos & Anders, 1992; Bulgren, Schumaker, & Deshler, 1988). Most importantly, these organizational strategies can be taught across the grade levels from elementary school through high school (Horton, Lovett, & Bergerud, 1990; Krishnan et al., 2010; Scanlon, Duran, Reyes, & Gallego, 1992). Many students, especially students with learning disabilities, struggle to organize and prioritize their ideas for summarizing, taking notes, and writing. They often need assignments to be broken down explicitly with organizers and templates that match both the goals of the assignment and their learning profiles (Graham & Harris, 2003; Harris & Graham, 1996). Two- and three-column outlining and note-taking strategies can provide this structure. For example, the Triple Note Tote strategy (ResearchILD & FableVision, 2003) guides students

to find the main ideas, differentiate the major concepts and details, "chunk" information into manageable parts, predict test questions, and develop strategies for memorizing information.

As students are required to manage a larger and larger volume of information while juggling the time they allocate to their homework, extracurricular activities, and social activities, strategies for organizing and prioritizing their lives assume increasing importance so that they can remain focused on their goals.

**Accessing Working Memory**

Working memory refers to the ability to store information for short time periods while simultaneously manipulating the information mentally, e.g., holding the main themes in mind while sorting through the details, or calculating a math problem mentally. Working memory is a critically important process that focuses the mind, directs mental effort, and also helps students to ignore distractions and to accomplish tasks (de Frockert, Rees, Frith, & Lavie, 2001; Swanson, 1999; Tannock, 2008). In fact, Baddeley (2006) and Swanson (Swanson & Sáez, 2003) have proposed that working memory often functions as the "central executive" that directs all other cognitive processes, including a student's ability to inhibit impulses, shift attention, and direct effort to the task. Working memory, therefore, plays a critical role in listening comprehension, reading comprehension, oral communication, written expression, and math problem solving, as well as efficient and accurate long-term learning (Swanson & Sáez, 2003).

Memorizing information in the classroom is heavily dependent on students' ability to focus and sustain their attention in order to make connections, retain information, and retrieve relevant details (Tannock, 2008). In fact, attention and memory are so strongly linked that the two processes are often viewed as part of the same executive process (Swanson & Sáez, 2003). To remember, retain, and retrieve information, students benefit from learning strategies for sustaining their attention, attaching meaning to information, and chunking information to reduce the memory load, as well as rehearsal and review (Kincaid & Trautman, 2010). When students are able to make meaningful associations, they are more successful with the transfer of information into long-term memory and later retrieval (Mastropieri & Scruggs, 1998).

From 4$^{th}$ grade onwards, academic tasks rely increasingly on these working memory processes. Consequently, strategic students are generally more successful than their less strategic peers on tasks that require them to focus on multiple processes simultaneously, such as following directions, responding to oral questions, and completing multi-step instructions (Kincaid & Trautman, 2010). Reading comprehension and written language are also heavily dependent on working memory. In these areas, students need to remember and manipulate multiple details, such as spelling and punctuation, while simultaneously focusing on remembering the main ideas, organizing their ideas, prioritizing important information, and figuring out which details to ignore. Young students may also need to think about handwriting and accurate letter formation, which may not yet be automatic for them. Similarly, summarizing, taking notes, and studying for tests require students to focus on

multiple processes simultaneously and to remember key ideas, formulate notes while listening, and identify major themes while writing (Kincaid & Trautman, 2010).

Given the heavy memory load imposed in our 21st century information-driven classes, and the emphasis on working memory and mental manipulation, it is particularly important to explicitly teach memory strategies to improve students' ability to retain and retrieve facts, processes, and concepts. Teachers need to help students to learn how to prioritize and select information to be memorized, in order to reduce the load on working memory. Most importantly, students need to be given sufficient time to process and practice memory strategies, and to develop their own personalized strategies for remembering challenging information. Strategies for organizing and prioritizing complex information often help students to bypass their working memory difficulties by reducing the memory load. Strategies for chunking information and retaining important details can help students to mentally manipulate information in working memory and to recall more information (Mastropieri & Scruggs, 1991, 1998; Scruggs & Mastropieri, 2000). Mnemonics, acronyms, and crazy phrases help students to connect new information to what they already know and to make meaningful connections to seemingly disconnected information (Carney, Levin & Levin, 1993). Different types of mnemonics improve retention of information and enhance working memory, in particular, keywords, pegwords, acronyms, acrostics, and visuals (Mastropieri & Scruggs, 1991, 1998; Scruggs & Mastropieri, 2000).

**Self-Monitoring and Self-Checking**

Self-monitoring refers to the ways in which learners manage their cognitive and metacognitive processes to track their own performance and outcomes (Zimmerman, 1998, 2000; Zimmerman & Kitsantas, 1997; Zimmerman & Schunk, 2001). The ability to self-monitor depends on students' metacognitive awareness, as well as their flexibility in shifting back and forth from the end-product of their efforts to the goals of the tasks. Students' self-monitoring strategies are linked with their ability to recognize why, where, when, and how to use specific strategies, to check the effectiveness of their strategy use, to evaluate and revise their strategy use, and to continually adjust their use of strategies based on the task demands (Bagnato & Meltzer, 2010).

Many students, especially students with learning and attention problems, have difficulty reflecting, monitoring their own learning, and evaluating the connections among their effort, strategy use and performance. As they focus their effort on reading, writing, math problem-solving and content learning, they may struggle to monitor their attention and performance, and may have difficulty shifting among a range of problem-solving approaches or strategies that are available to them (Graham, Harris, & Olinghouse, 2007; Klingner, Vaughn, & Boardman, 2007; Montague, 2003). Students therefore need systematic, structured, and scaffolded instruction so that they begin to use self-monitoring strategies flexibly in order to become independent learners (Graham & Harris, 2003; Reid & Lienemann, 2006). For example, personalized checklists and mnemonics can help students to edit their writing by focusing on their organization of ideas, sentence structure, use of

tenses, and spelling. Similarly, checklists and questions can encourage students to check back and forth between the computational details and the main ideas, for example: "Does my answer make sense?"

Numerous studies have shown that systematic teaching of self-monitoring strategies can improve performance significantly (Graham & Harris, 2003; Harris & Graham, 1996; Reid, 1996; Reid & Harris, 1993; Shimabukuro, Prater, Jenkins, & Edelen-Smith, 1999). Explicit, structured teaching encourages students to slow down and to allocate the necessary time to spiral back and forth so that they can check their own performance in relation to the demands of different tasks (Meltzer, Sales Pollica, & Barzillai, 2007; Reid & Lienemann, 2006). Furthermore, students learn to recognize the value of shifting mindsets in order to review their work (Bagnato & Meltzer, 2010; Meltzer & Basho, 2010).

In summary, effective self-monitoring requires students to reflect on their progress towards a goal, to select strategies that match their learning profiles, and to alter strategies that are not effective (Bagnato & Meltzer, 2010). As will be discussed in the next section, students' motivation and emotional mindsets frequently affect their willingness to make the often superhuman effort needed to stop, reflect, check and correct their work. These self-monitoring processes are critically important for long-term academic and life success.

## Emotional Self-Regulation

Students' attention and their ability to engage actively in the learning process are associated with their ability to regulate their emotions inside and outside the classroom (Brooks, 1991; Stein, 2010; Tangney, Baumeister, & Boone, 2004). The effects of emotion on the learning process follow a continuum. Specifically, extreme emotional reactions (e.g., anxiety, anger) often disrupt students' attention and ability to stay on task as well as their ability to learn and remember new information (Goldberg, 2001; Stein, 2010). In contrast, moderate emotional arousal has a positive influence on students' attention and executive function processes including working memory, cognitive flexibility, and inhibition (Gross, 2007; Stein, 2010). More specifically, the relationship between anxiety and performance is characterized by an inverted U-shaped curve. In other words, academic performance is often poor when students are not engaged and show low levels of anxiety, as a result of which they do not make the effort needed to succeed. At the other end of the spectrum, students' academic performance is compromised when their level of anxiety is so high that it interferes with their attention, working memory and overall performance (Goleman, 1995).

Students' self-understanding as well as their ability to regulate and shift their emotions are, therefore, important for efficient learning. As they develop strategies for regulating their emotional responses, they more easily attend to instructions, sustain their effort, and curb their frustration in response to difficult tasks (Stein, 2010). Self-regulatory strategies are particularly important for students with attention problems and learning disabilities. These students depend on structured approaches and routines that help to reduce

their emotional distractibility and impulsivity so that they can sustain their motivation and manage the many simultaneous demands of the classroom (Stein & Krishnan, 2007).

## The SMARTS and Drive to Thrive Programs: Blending Executive Function Strategies with Peer Mentoring

Building students' emotional self-regulation in conjunction with the other executive function processes can be accomplished through school and classroom-based programs that promote students' self-understanding, self-concept, and consistent use of executive function strategies while promoting effort, persistence, and resilient mindsets.

The *Drive to Thrive* and SMARTS programs focus on building a cycle of academic success in all students through teacher training supplemented by a peer tutoring and peer mentoring system (Meltzer, 2013a, b; Meltzer, Katzir et al., 2004; Meltzer, Noeder et al., 2007; Meltzer, Reddy, Pollica et al., 2004; Meltzer, Reddy, Sales et al., 2004; Meltzer, Reddy, Brach, Kurkul, Stacey et al., 2011; Meltzer, Reddy, Brach, & Kurkul, 2012). Teachers are trained to create a culture of strategy use in their classrooms and to promote metacognitive awareness in their students by embedding executive function strategies in their curriculum and daily teaching practices. The following principles guide the programs (Meltzer & Basho, 2010; Meltzer, Katzir et al., 2004; Meltzer, Reddy, Pollica et al, 2004; Meltzer, Reddy, Sales et al., 2004; Meltzer, 2007):

- Teachers understand and acknowledge the interactions among effort, strategy use, academic self-concept and classroom performance as well as the cycle that builds persistence, resilience and long-term academic success.
- Teachers foster metacognitive awareness and strategic mindsets in their students.
- Teachers acknowledge that effort is domain-specific and that students may sometimes work hard in one content area (e.g., math) and not another (e.g., language arts).
- Teachers acknowledge the importance of peer mentoring and peer tutoring and they build time and resources into the school day for the purposes of implementing a program such as SMARTS (see below).

- Teachers acknowledge that peer mentoring and peer tutoring provide a powerful forum for helping students to understand their learning profiles, to develop metacognitive awareness, and to recognize the important roles of executive function strategies as well as effort and persistence.
- Students view themselves as part of a community of learners who can help one another through peer mentoring and peer tutoring (see below). Emotional self-regulation is also strengthened as part of this program.
- Students understand that executive function strategies and focused effort are important for academic success.
- Students recognize that persistence and determination are critical for fostering academic and life success.

- Students begin to value the *process* of learning as they become cognitively flexible and learn to shift flexibly during problem-solving and other academic tasks.

One example of a school-based peer mentoring program is the recently-developed SMARTS Executive Function and Mentoring program (Gray, Meltzer, & Upton, 2008; Meltzer, 2013b; Meltzer, Reddy, Brach, Kurkul, & Basho, 2011; Meltzer, Reddy, Brach & Kurkul, 2012; Meltzer, Kurkul, Reddy, Greschler, & 2013). SMARTS is an acronym for Success, Motivation, Awareness, Resilience, Talents, and Strategies, each of which is a core component of the program. The SMARTS program focuses on promoting resilience and academic success by teaching executive function strategies and building metacognitive awareness and persistence in all students, particularly in students with learning and attention difficulties**.** Teachers are trained to implement the SMARTS Executive Function and Mentoring Curriculum which comprises thirteen strategies in the core executive function areas and includes tasks that:

- Increase students' metacognitive awareness, self-understanding, and academic self-concepts.
- Improve students' understanding and use of executive function strategies in six broad areas: goal-setting, organizing, prioritizing, using working memory, shifting flexibly, self-monitoring.
- Increase students' effort and persistence in school as well as their motivation to engage in the learning process and to improve their academic performance.
- Promote students' mentorship and leadership skills through peer mentoring.

Students are placed in mentor-mentee pairs and work together to learn and practice executive function strategies, with mentors coaching their mentees to build their self-confidence. To reinforce the learning and application of these strategies, the SMARTS curriculum culminates in a project that focuses on improving students' engagement, motivation, strategy use, and effort (Gray, 2007; Meltzer, Reddy, Brach, Kurkul, Stacey et al., 2011).

Findings from our recent SMARTS intervention studies with middle and high school students have highlighted the importance of strengthening students' self-understanding, cognitive flexibility, and flexible thinking (Meltzer, Reddy, Brach, Kurkul, & Basho, 2011; Meltzer, Reddy, Brach, Kurkul, Stacey et al., 2011; Meltzer, 2013b). Specifically, findings from one of our school-based studies showed that SMARTS students with higher cognitive flexibility scores were more goal-oriented, more persistent, and made greater effort in school (Meltzer, Reddy, Brach, Kurkul, & Basho, 2011; Meltzer, Reddy, Brach, Kurkul, Stacey et al., 2011). These more flexible students also used more strategies in their schoolwork and were more organized. Classroom teachers rated these students as having stronger academic performance and as checking their work more frequently (Meltzer, Reddy, Brach, Kurkul, & Basho, 2011; Meltzer, Reddy, Brach, Kurkul, Stacey et al., 2011). The social connections provided by peer mentoring increased students' engagement in the learning process as well as their goal-orientation and motivation. Overall, students' cognitive flexibility, academic self-

concept, and goal-orientation influenced students' effort, persistence, and academic performance.

These findings have relevance for teachers and emphasize the importance of increasing students' self-understanding, knowledge of executive function strategies, and academic self-concepts. Together, these initiate a positive cycle in which students show increased effort and self-concept, and more consistent use of executive function strategies, resulting in improved academic performance (Meltzer & Basho, 2010; Meltzer, Sales Pollica et al., 2007). Stronger academic performance helps students to feel more engaged and more invested in making the effort to use strategies in their classwork, homework and long-term projects, the foundations of academic and life success.

## Conclusions

Over the past few decades, technology has had a significant impact on the complexity and pace of the classroom curriculum and there is now greater emphasis on the importance of teaching students to problem-solve flexibly and to organize, prioritize, and self-monitor. For students with learning and attention difficulties, advances in brain-based measures will help us to refine our understanding of the effects of executive function weaknesses on academic performance as well as the efficacy of our interventions. These techniques will eventually help educators and parents to foster flexible thinking, effort, persistence, and resilience so that we can improve the long-term outcomes for students with learning and attention difficulties.

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