Cognitive Strategies Instruction: From Basic Research to Classroom Instruction

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Successful major league baseball managers are effectively strategic during games. They make decisions about who to put in the lineup based, in part, on their perception of which players are most likely to perform well against today's opposing pitcher. During the game, they make pitching changes when they feel their starting pitcher is no longer effective or seems to be getting tired, attempting to replace the starter with a relief pitcher likely to retire the next few batters. Their strategies are not static, but subject to change depending on their effectiveness. Individual strategies are often embedded in a network of strategies, with the baseball manager's strategy for getting the most out of his pitcher complemented by strategies for increasing run productivity and reducing the chances that a recovering player will be reinjured.

There are many, many problems that human beings attempt, with some strategies more likely to result in success than others. Understanding effective performance requires understanding the psychology of strategies; promoting human effectiveness at a task requires understanding of the strategies that can accomplish the task and how to develop such strategies among learners. Strategies development has deservedly received much study by cognitive psychologists, with educational psychologists doing much work to detail how affective, behavioral, and cognitive strategies develop, and can be developed, to increase student performance with respect to important academic tasks.

In this chapter, we begin with a definition of a "strategy" and brief discussion of constructs related to research in this area, including procedural and declarative knowledge, long and short-term memory, metacognition, and good information processing. We then turn to important findings from the earliest research on human strategies use, as these are critical to both understanding current research and to the development of further research. What we have learned about strategies use and strategies instruction in academic areas among students in the elementary through secondary grades then becomes the focus of this chapter.

STRATEGIES: DEFINITION AND RELATED CONSTRUCTS

The modern conception of strategies emerged in the 1950s, 1960s, and 1970s in the context of human information processing theory, rooted in strictly theoretical conceptions of information processing (e.g., Miller, Gallanter, & Pribram, 1960) and in models intended to promote learning of traditional school content, such as mathematical problem solving (e.g., Polya, 1957). Indeed, during this time there was much reflection and debate about what defines a strategy (Pressley & Harris, 2001).

Strategy Defined

As definitions of *strategy* evolved, one issue proved more debatable than any other. Must a strategy be used intentionally? Certainly, when people are first learning to use a strategy, they are very intentional, deliberately planning every move and monitoring its execution. With increasing expertise, however, what was once consciously deliberate becomes much more automatic, requiring much less conscious attention and reflection. That potential for conscious control is a critical part of the definition of strategy proposed by Pressley, Forrest-Pressley, Elliot-Faust, and Miller (1985, p. 4), a definition that has endured: "A strategy is composed of cognitive operations over and above the processes that are natural consequences of carrying out the task, ranging from one such operation to a sequence of interdependent operations. Strategies achieve cognitive purposes (e.g., comprehending, memorizing) and are potentially conscious and controllable activities."

Procedural and Declarative Knowledge

Strategies are knowledge of procedures, knowledge about how to do something—how to decode a word, comprehend a story better, compose more completely and coherently, play first base better, and so on. Such knowledge contrasts with declarative knowledge, the knowledge of facts (Mandler, 1998). Of course, procedural and declarative knowledge are not unrelated, with declarative knowledge potentially impacting execution of even an overlearned procedure (Rabinowitz, 2002). Indeed, there is growing realization that interventions promoting procedural learning include aspects that increase learning of declarative information that can interactively support and complement the procedural knowledge. Thus, when students are required to explain their problem-solving strategies, as they do geometry problems, their understanding and transfer of strategies increases. Such an increase is probably because self-explanation promotes development of both declarative and procedural knowledge about problem-solving situations (Burkell, Schneider, & Pressley, 1990). Further, more sophisticated strategies use often results in increases in declarative knowledge (Kuhn & Udell, 2003).

Throughout the discussion that follows, there will be many instances where declarative and procedural knowledge intermingle. For example, word decoding strategies make use of factual knowledge of letter-sound associations. Comprehension strategies like

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predicting ideas in text require prior knowledge about the topic of the text. Written composition depends on strategies to organize content the writer already knows or has found through research.

Long- and Short-Term Memory

Both procedural and declarative knowledge reside in long-term memory, most of which is out of consciousness most of the time, retrieved and activated only when the knowledge is needed. Much of human intelligence is such knowledge, referred to as crystallized knowledge in Horn and Cattell's theory (1967). Active thinking, however, takes place more in working memory, the part of intelligence that permits active reflection on and manipulation of information (Baddeley, 2003). That is, when the contents of long-term memory are activated, they are activated into this working memory system, where the contents are thought about with respect to a current task demand (e.g., understanding a story, writing a text, solving a problem).

One of working memory's most salient characteristics is that it is extremely limited. There is only so much that a person can consciously think about at any given time. Another salient characteristic is that some people's working memories seem to be greater in capacity, with smaller working memory associated with a variety of learning and language disorders (e.g., Swanson & Saez, 2003).

So, how does information get activated into working memory? Some activation is automatic and associative, not much under the thinker's control. Other activation is quite controlled, with the thinker very deliberately activating that knowledge. Thus, on hearing a rate-distance problem, an effective algebra student immediately activates the strategies known for solving such problems. A less effective student might not do so, but would be able to apply such strategies if someone reminded her or him that these are the strategies to apply to this type of problem. The difference between effective and less effective performance is often related in part to metacognitive understanding of when and where to apply known strategies.

Metacognition

Metacognition is knowledge of cognition, including knowledge about the value of cognitive strategies. People are much more likely to continue using a strategy they have learned if they understand that the strategy does have a positive impact on performance (Pressley, Borkowski, & O'Sullivan, 1985). A related and equally important form of metacognition is knowing when and where particular cognitive strategies should be used, sometimes referred to as *conditional knowledge* (Paris, Lipson, & Wixson, 1983). Such conditional knowledge is essential for broad and appropriate use of cognitive strategies (Borkowski, Carr, Rellinger, & Pressley, 1990; O'Sullivan & Pressley, 1984). Deciding to use strategies requires effort, which explains why strategy utility knowledge is so important. As a general rule, people do not expend effort unless they expect payoff. Knowing that a strategy will produce impact can motivate the use of strategies, if the impact matters to the thinker (Borkowski et al., 1990).

Good Information Processing

In the late 1980s and early 1990s, Pressley, Borkowski, Schneider, and their associates conceived of effective strategies use as good information processing (e.g., Pressley, Borkowski, & Schneider, 1987; Schneider & Pressley, 1997). Such thinking depends on intact working memory capacity and long-term memory. The long-term memory of the good information processor includes well developed procedural and declarative knowledge as well as extensive metacognition, especially conditional and strategy utility knowledge. The good information processor is also motivated to use her or his strategies and knowledge, recognizing that good performance depends more on effort expended on task-appropriate strategies, rather than to factors out of her or his control, such as native ability, ease of the task, or luck (Borkowski et al., 1990). All of the main tenets of this perspective remain intact in more contemporary elaborations of effective information processing (e.g., Alexander, 2003).

The good information processing perspective proved to be remarkably uncontroversial, perhaps reflecting that it was constructed in light of a great amount of data on strategy development, including through instruction, that were generated in the 1960s, 1970s, and 1980s. Understanding the main findings from this literature on strategy development is essential to understand current research and theory regarding strategies. Thus, before turning to the literature on strategies instruction in educational arenas, we turn to basic research on cognitive strategies instruction and cognitive development.

THE DEVELOPMENT OF STRATEGIC COMPETENCE: UNDERSTANDINGS FROM BASIC RESEARCH

Without a doubt, the most complete study of strategic competence has been conducted in the area of children's memory (Schneider & Pressley, 1997). Thus, much of what follows in this section is about memory development. Basic research studies of other aspects of thinking and learning, including elementary problem solving, scientific thinking, and critical thinking, have been conducted and also inform this summary of basic understandings about strategic competence.

Initial Research: Elementary Grade Children

Interest in strategies development increased dramatically with the publication of a study by Flavell, Beach, and Chinsky (1966). The investigators presented children with a list of pictures to memorize in order. The participants in the study were between 5 and 10 years of age. Flavell and his associates were especially interested in what the children did to memorize the pictures and if developmental differences in what children did to memorize might account for differences in memory performance. The outcomes of the study were clear. With advancing age, recall improved as did use of a particular memory strategy. With increasing age, children were more likely to rehearse the names of the objects depicted.

Keeney, Cannizzo, and Flavell (1967) extended the Flavell et al. (1966) study. They investigated what happened if young children, who did not rehearse on their own when presented a list to learn, were taught to do so. Primary-grades students easily learned how to verbally rehearse pictures lists, with the result increased recall of the pictures on the list. Children could be taught a memory strategy that they did not think of on their own. Rehearsal was established as a causal mechanism in children's memory, a mechanism that kindergarten students used much less than students in the middle elementary grades.

Flavell's early work stimulated a number of investigations of children's use of rehearsal strategies, both when children were left to their own devices to memorize and when they were instructed to use rehearsal strategies (e.g., Cuvo, 1975; Gruenenfelder & Borkowski, 1975; Hagen, Hargrave, & Ross, 1973; Kingsley & Hagen, 1969; Naus, Ornstein, & Aivano, 1977; Ornstein, Naus, & Liberty, 1975). There was great convergence across these studies. First of all, the last items on the picture list tended to be better recalled than items in the middle of the list, reflecting that the last few items continued to be active in working memory, and, hence, were easily remembered. Better recall of the last items on a list came to be known as the *recency effect*. The first few items on the list tended to be remembered better than items in the middle of the list, referred to as a *primacy effect*. Primacy effects, in particular, were developmentally sensitive, with children in the middle elementary grades more likely than younger children to remember the initial items on a list, reflecting that older children rehearsed the list items more than younger children.

Across studies, it was quite clear that when nonrehearsing children were taught to rehearse list items, a primacy effect would occur, strengthening causal conclusions: That is, instruction to rehearse increased previously nonrehearsing children's visible rehearsal of the items on lists, with memory increased especially for the items that were most rehearsed, the beginning of the list items. Young children's failure to use rehearsal strategies on their own came to be known as a *production deficiency* (Flavell, 1970), a deficiency that could be overcome with instruction. As will become clear as this chapter proceeds, researchers have discovered many production deficiencies as they have studied children's cognition, occasions when students fail to produce a strategy that could help them do a task, although they can be taught to use the strategy in that situation (Pressley & Hilden, in press-a).

We emphasize at this juncture that Flavell's early work would set the stage for the study of memory strategy development, including strategy discovery and acquisition through instruction, during the preschool years, the years of elementary schooling, and beyond through middle school and high school. More generally, Flavell's (1970) work would go far to encourage the perspective that children can be taught to use strategies that they often do not produce on their own.

Preschool and Primary-Grades Years: New Understandings

One conclusion in the work just reviewed was that preschoolers did not use rehearsal strategies for learning lists of items. Does that mean preschoolers are never strategic? One possibility was that picture list learning was just a very strange situation for kindergarten-age children, that young children might perform more competently if given tasks more consistent with ones they encountered in their everyday lives. To find out, researchers studied memory situations more familiar to young children.

Strategies production. DeLoache, Cassidy, and Brown (1985) reported one of the most important studies of strategies use by preschoolers. The study took place in a living room, with an experimenter hiding a Big Bird doll under a pillow on a couch. When the experimenter asked children 18 months to 2 years of age to remember where the doll was hidden, the children looked at the hiding place until it was time to retrieve the doll. Even when the experimenter tried to distract the preschoolers, they kept looking back at the pillow on the couch. In one condition of the study, rather than putting Big Bird under the pillow, the experimenter put the doll on the pillow, in full view of the participant. In this situation, there is no memory requirement. Accordingly, the children did not look back at the doll. That is, only when there was a memory requirement (i.e., the doll was hidden under a pillow) did the children evidence any strategies to remember where the doll was. This was the first of several studies making clear that even 2- to 3-year-old children can be strategic when confronted with a familiar task (see also Haake, Sommerville, & Wellman, 1980).

Other demonstrations of preschool use of memory strategies were generated in the 1980s. Thus, Baker-Ward, Ornstein, and Holden (1984) showed that preschoolers were much more strategic when they were asked to remember a group of toys than when they were instructed to play with the toys. When asked to remember the toys, they tend to say the names of the toys more often than when directed to play with the toys. Preschoolers certainly understood, at least in some situations, that remembering calls for different processing than playing.

Utilization deficiencies. Something that was quite interesting in the Baker-Ward et al. (1984) study was that, often, even if 4- and 5-year-olds tried to remember a group of toys by saying and repeating the names of the toys, their efforts did not increase their memory. When children execute a strategy and it does not increase memory, the phenomenon is known as a *utilization deficiency* (Miller & Seier, 1994). Such utilization deficiencies were observed in several very well controlled studies of preschoolers' memory strategy use (e.g., Lange, MacKinnon, & Nida, 1989; Newman, 1990). Why utilization deficiencies occur still is not well understood, although there is some evidence that such deficiencies are linked to working memory capacity limitations during preschool and the early elementary years (Woody-Dorning & Miller, 2001).

Mediation deficiencies. Sometimes when young children are asked to use a memory strategy, the problem is that they cannot execute the strategy, cannot construct the mediator they are being asked to construct, a difficulty referred to in the literature as a *mediation deficiency* (Reese, 1962). This seems to be the case when 4- to 7-year-old children are asked to generate mental images, for example, representing ideas expressed in a text they read or hear (see Pressley, 1977, for a review of the data). The likely culprit is limited working memory capacity in young children (see analyses by Cariglia-Bull & Pressley, 1990; Pressley, Cariglia-Bull, Deane, & Schneider, 1987), a problem perhaps accentuated by the fact that internal cognitive operations are performed more slowly by younger compared to older children, with slower operations consuming more working memory capacity to execute.

Retrieval deficiencies. Finally, even if children construct a mediator, sometimes they will fail to use it later when they are required to remember what they studied, a failure known as a *retrieval deficiency* (Kobasigawa, 1977). That is, even if students construct mental images that have the potential to increase their later memory of material, it does little good if they do not think to use their previously constructed images at test time. More positively, at least on some occasions, a reminder to think back to strategies used at study and the mediators constructed at study is all that is required to get students to search their memories and use the mediators they constructed previously, thus, increasing memory performance on a test (e.g., Pressley & MacFadyen, 1983).

These historical findings should be understood better by many educational psychologists, for they make clear that strategies use by young children is more complicated than many practitioners believe. Indeed, some prominent recommendations regarding strategies use in the practitioner literature may, in fact, be wrong. For example, there are many suggestions in the practitioner literature that it makes sense to teach early primary grades children to construct mental images representing the ideas expressed in stories (see Miller, 2002). This recommendation flies in the face of voluminous basic research data that such children experience great difficulties in generating images representing the ideas in stories (Pressley, 1977), even when given strong support for doing so (e.g., partial pictures that strongly suggest the parts of the picture that could be imagined by the child (Guttmann, Levin, & Pressley, 1977). More careful study of the substantial basic research literature could result in a more informed applied science with respect to strategies instruction as well as more complex study of strategies development and instruction.

Strategies Development Discovery, Direction or Instruction?

As a general rule of thumb, across many domains, there is evidence of greater strategy use with increasing age/grade level, proceeding through middle and late elementary grades, middle school, high school, and college (see Pressley & Hilden, in press-a, for a review). Questions of enduring significance are whether, when, and how young children discover strategies for performing academic tasks. There can be no doubt that even 2- and 3-year olds discover some strategies, for example, keeping their eyes on a hidden toy in order to remember where it is. Other strategies are learned later, as a function of new task demands on children. Nonetheless, often children and adults do not discover and use the most potent strategies possible as they confront academic tasks.

For example, Kuhn and her colleagues (Kuhn et al., 1988) studied whether children and adults use a controlled comparison strategy as they tried to decide which characteristics of a set of balls (e.g., size, rough or smooth) determined whether a ball could be reliably served in a paddle game. The most efficient strategy was to compare balls that differed with respect to only one characteristic (e.g., large or small), repeating such trials until all of the dimensions of difference were assessed. Although there was improvement from childhood to adulthood in use of the controlled comparison strategy, even college students often failed to be maximally systematic as they evaluated characteristics of balls that could affect bounce.

Kuhn (1991) extended her work on strategy use by evaluating the social scientific reasoning strategies of children and adults as they constructed arguments about important social problems, such as the causes of criminal recidivism, school failure, and unemployment. Both children and adults had difficulties reasoning on several sides of these issues, difficulty in generating counterarguments to the arguments of others. In short, there was not much evidence that either children or adults used sophisticated critical thinking skills (see Baron & Sternberg, 1987; Perkins, Lochhead, & Bishop, 1987).

More positively, there is evidence that children sometimes do discover strategies as they do tasks, although some situations make that more likely than others. For example, Kuhn and Udell (2003) studied argument skills in inner city students in grades 7 and 8. Students who favored and opposed capital punishment prepared for a showdown debate on capital punishment. The control participants experienced some dyadic practice in arguing about capital punishment, working with peers (but supported by teacher scaffolding) to generate and refine arguments in favor of their position on capital punishment. Participants in the experimental condition received the same dyadic practice as controls but also participated in scaffolded, dyadic practice that led them to generate counterarguments to criticisms of their position, focusing on rebuttals of opposing positions. The experimental condition also provided opportunities to think and reason about mixed evidence. The most important finding was that the experimental participants evidenced more growth in argument strategies from pretest to posttest than control participants. In particular, they improved in making counter-arguments with respect to the position on capital punishment that they opposed. The experimental participants also increased their knowledge of the topic of capital punishment as a function of the dyadic experiences in generating counter-arguments. That is, consistent with other evidence reviewed later, more sophisticated strategies use often results in increases in declarative knowledge.

Although there is improvement in performance in reasoning and argumentative skills with practice and reflection, there is also a great deal of variability from trial to trial and task to task, with children and adults normally using a mix of strategies, some more effective than others (e.g.,Kuhn, 1995; Kuhn, Garcia-Mila, Zohar, & Andersen, 1995). Such variability in strategies use is apparent even in some more basic task situations, ones simple enough that there are single strategies that can effectively mediate performance (cf. Pressley & Levin, 1977). More positively, there is evidence that some later-elementary and middle school-age children mix effective and ineffective strategies but shift to more exclusive use of effective strategies with practice (Schlagmueller & Schneider, 2002). Moreover, some high ability child learners do use effective memory strategies very consistently (Coyle, Read, Gaultney, & Bjorklund, 1998).

In short, although there is increased use of more effective strategies with advancing age, we have encountered little evidence in any task domain that children certainly discover and consistently use the most effective strategies that can be used to accomplish tasks. Of course, this finding is in synchrony with a generally poor record for discovery learning (Mayer, 2004). Even when people discover effective strategies, they then tend to use them variably. Still, we know little about the defining characteristics of such situations. More positively, however, there is one approach that works better than any other for ensuring that learners actually learn strategies: strategies instruction. Some important, analytical work in strategies instruction first occurred with respect to very basic memory strategies.

Strategies Instruction: Early Issues of Maintenance and Generalization

There was incredible consistency in the basic research literature with respect to the issue of instruction: For many basic memory tasks, from learning lists of pictures to recalling main ideas and details from texts, children can learn effective strategies when they are taught to them with clear benefits in learning and memory. By the early 1980s, this conclusion held for normally achieving children, students with learning disabilities, and children with mental retardation (Pressley, Heisel, McCormick, & Nakamura, 1982). Moreover, by the early 1980s, it was apparent that a variety of strategies increased performance in basic memory and learning tasks (Pressley et al., 1982).

One troubling finding in the early strategies instruction literature was that students often did not continue to use strategies they were taught, both failing to maintain the strategies (i.e., using them with materials similar to the materials they experienced during strategies instruction) and failing to transfer them (i.e., use taught strategies in new situations where they could be deployed profitably). One of the most important analyses of how to increase continued use of strategies was produced by Belmont, Butterfield, and Ferretti (1982). They were particularly interested in the potential of strategies functioning for students with mental retardation, analyzing about 100 studies of strategies instruction with people afflicted by retardation. They discovered an important regularity: Students with mental retardation did evidence transfer of strategies taught when instruction was rich in encouraging metacognitive understanding of strategies. Thus, when strategies transfer occurred, learning goals were definitely emphasized as was the necessity of planning as part of tackling academic tasks. Students were encouraged to monitor whether using the strategy was improving performance (e.g., asking themselves, "Did the plan work?"). Maintenance and transfer also was more likely if students were taught to cope if they experienced some failure or frustration, taught to consider making and trying a new strategy.

Belmont et al.'s (1982) analysis made very clear that strategies instruction could be very potent even with students at risk for academic failure (i.e., students with retardation). This complemented work with normal and less disabled children, research establishing that children in general were more likely to continue to use and transfer strategies if strategies instruction and practice included opportunities to learn when and where the strategies worked, the benefits produced, and how the strategy might be adapted to new situations (O'Sullivan & Pressley, 1984; Pressley, Borkowski, & O'Sullivan, 1985). That is, children proved more likely to maintain and transfer strategies they learned if instruction was metacognitively rich.

STRATEGIES USE AND INSTRUCTION IN ACADEMIC AREAS

Strategies use and instruction has been more prominent in some academic areas than in others. In this section, we discuss work in four areas where there has been extensive consideration of the role of strategies in academic cognition: reading, writing, foreign language learning, and mathematical problem solving. Issues and commonalities across these areas are then noted in the final section of this chapter.

Reading

Researchers have learned a great deal about skilled reading. One method, verbal protocol analyses, has been particularly useful in understanding skilled, and less skilled, reading (Pressley & Afflerbach, 1995). Skilled readers are actively predictive as they read, developing expectations about upcoming text in reaction to the title, section headers, pictures and other clues, basing their predictions in part on prior knowledge they possess about the topic of the text. Throughout reading, good readers connect ideas in a current text to their general and specific understandings of and opinions about the world. They ask questions as they read and look for answers. Good readers create envisionments of the settings, characters, and events portrayed in text. They also consciously reflect on what the big ideas are in text and construct personal interpretations of what they read. Often, reading is anything but linear, with readers jumping back and forth in text. Moreover, good readers recognize that not all parts of text deserve equal attention, with them adjusting their reading rate and analytic set as they go through the text, reading more carefully some sections than others (Anderson, 1992; Brown, Pressley, Van Meter, & Schuder, 1996; Collins, 1991).

In contrast, weaker readers are much more likely to read word by word, reading less actively, a strategy that certainly produces some understanding, often enough to do well on simple, multiple-choice comprehension tests. Weaker readers face a number of problems as they seek meaning from text.

Two problems have consumed researchers interested in reading more than other problems: The first is how children can be taught to read words, and the second is how children and adults can be taught to process text so as to increase comprehension. Both are tasks that can be accomplished strategically, and researchers have invested considerable effort to identify strategies that can be taught to promote both word recognition and comprehension as well as to identify how such strategies can be taught so that students, in fact, use the strategies and use them appropriately.

Word recognition. Good readers recognize most words automatically but are capable of consciously sounding out unfamiliar words; this is possible because of their understanding of the letter-sound associations in English. The goal in teaching children to read words is to get them to that point at which they automatically recognize most words and sound out words they do not recognize.

Most children arriving at the kindergarten door cannot read many words if they can read any at all. More positively, an important finding in 20th century educational science is that many children can make great progress in learning how to read words by teaching them phonics strategies. That is, children can be taught the letter-sound associations in English and taught to make the sounds represented by the letters in a word, blending those sounds to pronounce the word. That this approach works much of the time was one of the most important conclusions in the National Reading Panel (2000) report. Awareness of the power of teaching young children sounding out strategies has had broad impact. The most recent federal elementary and secondary school act (107th Congress, 2002), the *No Child Left Behind (NCLB)* legislation, mandates teaching primary-grades students phonics strategies in those elementary schools receiving *NCLB* funds.

That said, phonics instruction's impact on beginning reading is not large, with a moderate-sized effect in meta-analytic terms (Cohen, 1998). One reason that the impact is modest is that teaching phonics strategies does not work all of the time. Consider a couple of recent studies. Morris, Tyner, and Perney (2000) provided tutorial reading instruction to grade 1 students in the lowest 20 percent of their classes (i.e., with respect to reading achievement). The tutoring included a great deal of explicit, systematic phonics instruction, with most participants who received the tutoring experiencing great growth, especially relative to control participants. That said, about 7 percent of the participants made little to no progress. Similarly, Fuchs et al. (2001) provided intense phonics instruction to kindergarten students in intact classes for about 20 weeks. It worked for most students, but for a few there were no gains.

What bothers us is that so little is known about why phonics instruction does not work when it does not work. We think it would make sense to study such children's performance carefully, considering the possibility that some of the deficiencies noted in basic strategies research might have counterparts with respect to phonics strategies. Thus, are there children who simply cannot sound out words no matter how hard they try, a phonics mediational deficiency? Or perhaps they can sound out words but somehow the sounding out does not click as a word—that is, the student sees *ball* and sounds out /*b*/ followed by /*a*/ followed by /*l*/ but does not make the connection that this sounded-out word is the same as that word in their oral vocabulary, *ball*, that refers to a round, bouncy thing. This would be a utilization deficiency. Alternatively, what if the child learns how to sound out phonetically and yet does not transfer the approach to new situations, such as reading on a standardized test? In short, there are a number of possible ways that phonics may not work.

We suspect that skilled reading clinicians might be able to think of interventions for dealing with mediation deficiencies, utilization deficiencies, or transfer failures. For example, failure to transfer phonics might be addressed by providing meaningful metacognitive embellishment to phonics instruction, making clear that phonics can and should be used whenever unfamiliar words are encountered. Phonics can and should be studied as basic strategies have been studied, and failures of phonics be examined as potentially similar to other strategy failures.

The most popular strategies-oriented hypothesis with respect to phonics is that some students respond better to some forms of phonics instruction than others, although this hypothesis is not so well developed that there has been a true test of the suggested aptitude by treatment interaction. Nonetheless, Lovett and her colleagues have examined the relative efficacy of two popular forms of phonics instruction, their impact alone and in combination. Since Chall's (1967) analysis, synthetic phonics has been the most prevalent phonics strategy taught. This involves teaching students the letter-sound associations and then teaching them to blend sounds to recognize words. An alternative is to teach students to focus on larger word parts, making maximum use of the many word families in English (e.g., focus on the *-ight* in *might, sight, light* and so on; focus on the *-aid* in *raid, laid,* and *paid*) as well as the common prefixes and suffixes, teaching students to decode new words through analogy to known words (e.g., to read a new word, *fade* by analogy with a known word, *made*).

The participants in Lovett et al. (2000) were 6- to 13-year-olds who experienced severe problems learning to read. These students were provided 70 hours of intervention in the study. In one condition, students received only synthetic phonics instruction. In a second condition, they received instruction emphasizing decoding by analogy with known words. In a third condition, students were taught both synthetic phonics and decoding by analogy. Students in a control condition were taught math skills and classroom survival skills. The results were very clear. After instruction, students taught the decoding strategies could read words better than control participants, with reading in the combined synthetic phonics and analogy condition exceeding reading in either the synthetic phonics alone or analogy alone condition, with performances in those conditions not varying.

It is also apparent that one type of decoding instruction does not work with all learners. Moreover, it seems likely that the effectiveness of the various decoding strategies will vary with word characteristics: Words having salient parts that are common to other words are likely susceptible to recognition through analogy (e.g., recognizing *spat* as analogous to *sat*, *fat*, *pat*, and so on). In contrast, more morphologically unique words may be better sounded out by blending the component sounds as represented by the individual letters and letter clusters (e.g., digraphs) in the words.

Lovett, Barron, and Benson (2003) are currently evaluating an intervention that involves teaching struggling beginning readers to use five strategies as a repertoire: (a) sounding out words by blending individual sound; (b) decoding by analogy to known words, focusing on whether an unknown word might rhyme with a known word; (c) peeling off prefixes and suffixes and isolating a smaller root word; (d) trying each of the sounds a word's vowels could make; and (e) looking for smaller, known words in a longer unknown word. Lovett et al. (2003) have been very much influenced by researchers who emphasize teaching students to self-regulate their use of strategies, who emphasize metacognitively embellishing strategies instruction (e.g., Harris, 1982; Harris & Graham, 1992; Meichenbaum & Biemiller, 1998).

For example, while trying to decode the word *unstacking*, students would self-regulate strategy use through four steps (Lovett et al., 2003, p. 285, Table 17.1): (a) They would choose a strategy, saying to themselves something like the following: "My game plan is first to use peeling off. Then I am going to use the rhyming strategy and look for the spelling patterns I know." (b) The students would use these strategies, self-verbalizing as they do so: "I am peeling off *un* and *ing*. My next game plan is rhyming. I see the spelling pattern *-ack*. The key word is *pack*. If I know *pack*, then I know *stack*." (c) The reader would then check: "I have to stop and think about whether I am using the strategies properly. Is it working? Yes, I'll keep on going. I will put all the parts together—*un-stack-ing*." (d) The student self-reinforces by declaring she or he "scored," if the word seems correct. If not, the student would start the sequence again, choosing, using, and checking strategy use: "The word is *unstacking*. I scored. I used peeling off and rhyming to help me figure out this word and that worked." Evaluations of this self-instructional approach are now underway, with our expectation that there will be increased study of how to increase beginning readers' self-regulated use of a variety of strategies that can be used to decode unfamiliar words, with the goal of developing beginning readers who continue and generalize use of effective word recognition strategies.

Comprehension. In the 1970s and early 1980s, the study of comprehension was largely the evaluation of individual comprehension strategies (e.g., prediction, question asking, imagery generation, monitoring and seeking clarification when confused, summarization). In a typical study, one group of young readers would be taught to use a particular strategy and a control group would be left to their own devices to read and understand text. In general, a variety of individual strategies proved effective in promoting reading comprehension, often assessed by answering questions about a text just read or simply retelling the text just read (e.g., Pearson & Fielding, 1991; Pressley, 2000; Pressley, Johnson, Symons, McGoldrick, & Kurita, 1989).

Good readers do not rely on individual strategies, however, as they read text, but rather articulate a repertoire of strategies, flexibly applying and adapting individual comprehension strategies before they read a text, while they are reading, and after they conclude a first reading of a document (Pressley & Afflerbach, 1995). In the 1980s, researchers turned their attention to teaching elementary and middle school students repertoires of comprehension strategies, with improved comprehension generally following such instruction (e.g., Bereiter & Bird, 1985). The best known of such instructional interventions was reciprocal teaching (Palincsar & Brown, 1984; Rosenshine & Meister, 1994), which involved teaching students to make predictions, ask questions, seek clarification when confused, and summarize. When deployed in classrooms, however, there often was departure from the version of reciprocal teaching developed and studied by Palincsar and Brown, with students using the strategies very flexibly (and not necessarily in the originally proposed order). In addition, Palincsar and Brown advocated strategies development in the context of small group reading, with students in the group taking turns leading the group as it applied strategies to reading. In classrooms, however, teachers who employ reciprocal teaching as a way to begin strategies instruction eventually use a variety of instructional tactics to encourage their students to make predictions, generate questions, seek clarifications, and construct summaries (Hacker & Tenent, 2002; Marks et al., 1993).

Indeed, many educators came to teach comprehension strategies in a more flexible manner than reciprocal teaching. Pressley, El-Dinary et al. (1992) coined the term *transactional comprehension strategies instruction* to emphasize that teachers and students often flexibly interacted as students practiced applying strategies as they read. Students in transactional strategies instruction are encouraged to use the comprehension strategies that seem appropriate to them at any point during a reading. There is dynamic construction of understanding of text when small groups of children make predictions together, ask questions of one another during a reading, signal when they are confused, seek help to reduce confusion, and make interpretive and selective summaries throughout a reading and as a reading concludes.

There are several very good evaluations of transactional strategies instruction (e.g., Anderson, 1992; Collins, 1991). Brown et al. (1996) studied grade 2 students, who received transactional comprehension strategies instruction over the course of the grade 2 school year or who experienced conventional reading instruction that year. The strategies were taught directly in small reading groups, through teacher modeling and explanations, followed every day by application of the strategies to stories being read in reading groups. Although at the beginning of the school year the two groups did not differ on any measures of reading achievement, by the end of the school year, the group taught comprehension strategies using the transactional approach outperformed control participants on a wide variety of measures, from standardized test performance to remembering more content from stories read during reading group. In general, consistent with Anderson (1992) and Collins (1991), the effects of a year of comprehension strategies instruction were large in Brown et al. (1996) and apparent in many ways (i.e., not just on standardized tests but on other measures, both quantitative and qualitative).

During the past half dozen years, there has been increasing awareness of how difficult it is for teachers to learn how to teach comprehension strategies (Pressley & El-Dinary, 1997). As this chapter is being written, Hilden, Moxley, and Pressley are collecting data on the many challenges to effective comprehension strategies instruction in elementary and middle schools. The problems range from teachers not understanding the approach because they do not read using consciously controlled comprehension strategies to lack of school resources to provide in-class coaching to teachers about comprehension strategies instruction. Just as was the case a generation ago (Durkin, 1978–79), there is still too little comprehension instruction occurring in schools (Pressley, Wharton-McDonald, Mistretta, & Echevarria, 1998; Taylor, Pearson, Clark, & Walpole, 2000).

Writing

Learning to write is difficult and demanding, as writing is a highly complex process. The good writer must not only negotiate the rules and mechanics of writing, but also must maintain a focus on important aspects of writing, including organization, form and features, purposes and goals, audience needs and perspectives, and evaluation of the communication between author and reader (Applebee, Langer, Mullis, Latham, & Gentile, 1994; Bereiter & Scardamalia, 1982; Hayes, 2004; Hayes & Flower, 1980). In addition, writing requires extensive self-regulation, persistence, and attention control (Graham & Harris, 1994, 2000). In its report, *The Neglected "R,"* the National Commission on Writing in America's Schools and Colleges (2003) expressed strong concern with the narrative, expository, and persuasive writing of students in the United States. Scardamalia and Bereiter (1986) identified five areas of writing competence particularly difficult for most students: (a) generating content, (b) creating an organized structure for compositions, (c) formulating goals and higher level plans, (d) quickly and efficiently executing the mechanical aspects of writing, and (e) revising text and reformulating goals.

Good writers, in contrast, engage in purposeful and active self-direction of the processes and skills underlying writing, and like good readers, use a repertoire of strategies. Seminal research by Hayes and Flowers (1980), involving analysis of "think aloud" protocols, provided a window into the cognitive processes of good writers and led to the development of an influential model of skilled writing. For skilled writers, the process of writing is goal-directed; they organize and execute their goals flexibly, switching from simple to complex goals while drawing on a rich store of cognitive processes and strategies for planning, text production, and revision. Good writers also have knowledge of the organizations typifying different genres; can develop novel or modified organizations as needed; are sensitive to the functions of their writing; and attend to the needs and perspectives of their audience (Harris & Graham, 1992).

Study of good writers and the development of expertise in writing, combined with recognition of the difficulties many children face in learning to write, fueled interest in instruction in writing from cognitive theoretical perspectives in the 1980s (Scardamalia & Bereiter, 1986). The largest body of research in the area of writing performance, however, has evolved in the area of strategies instruction.

Writing strategies instruction. Most writing strategies instructional research has primarily involved either participants with learning disabilities or students who struggle with writing, typically defined as scoring in the lower quartile on norm-referenced measures (Harris & Graham, 1992). An important by-product of writing instructional research with students with learning disabilities is that what works for these students also improves performance of average and good writers (Englert et al., 1991; Graham, in press; Graham & Harris, 2003; Wong, Harris, Graham, & Butler, 2003). A number of researchers have carried out important studies of writing strategies instruction (for a complete list, see Graham, in press). Three major lines of research are especially notable, however, having had broad impact.

Englert and her colleagues published two influential studies involving elementary students with learning disabilities, using their Cognitive Strategies Instruction in Writing (CSIW) program (Englert, Raphael, & Anderson, 1992; Englert et al., 1991). "Think sheets" are used in CSIW to prompt students to carry out specific activities during writing processes, including: planning, organizing information, writing, editing, and revising. A number of features common to strategies instruction models are used to aid students in coming to own and internalize the strategies and framework represented on the think sheets, including teacher modeling, self-instructions, gradually faded support, and helping students understand what they are learning, why it is important, and when it can be used.

In the Englert et al. studies, students with and without learning disabilities improved their knowledge of the writing process and their writing abilities. Most impressive, students with learning disabilities performed similarly to normally achieving peers on all five posttest variables after CSIW instruction. Consistent with the good information processor perspective, metacognitive knowledge was positively related to measures of performance, both for writing and reading.

Wong and her colleagues (1994, 1996, 1997) are among the few researchers who have conducted writing strategies research among secondary students, validating genre-specific strategies (personal narrative, opinion essays, and compare and contrast essays) in a series of three studies involving students with learning disabilities (Wong, Butler, Ficzere, & Kuperis, 1997; Wong, Butler, Ficzere, & Kuperis, 1996; Wong, Wong, Darlington, & Jones, 1991). They considered several critical principles in designing their strategies instruction, including the need to develop among these students procedural and declarative knowledge of the writing process, understanding of the recursive nature of the writing process and the importance of planning and revising, and important knowledge about good writing (being clear for the reader, good work choice, importance of powerful introductions and conclusions, cadence, and so on). Heeding the call for addressing affective needs and characteristics of learners in good strategy instruction, Wong and her colleagues included development of self-efficacy for writing and positive attitudes about writing in their instructional approach.

Writing strategies instruction was effective for the secondary students in these studies, with instruction increasing both the quality and quantity of what students wrote across the three genres. Students with learning disabilities, however, needed more instruction and opportunities to write in order to reach a satisfactory level of performance in each genre than did their normally achieving peers. Far more research in secondary writing strategies instruction is needed.

Harris and Graham have provided detailed discussions of the multiple, integrated theoretical and research roots of the Self-Regulated Strategy Development (SRSD) model (Harris, 1982; Harris & Graham, 1992; Harris et al., 2003). Since 1985, more than 30 studies have been reported using the SRSD model of instruction in the area of writing, involving students in the second through eighth grades (Graham, in press; Graham & Harris, 2003; Graham et al., in press; Wong et al., 2003), including randomized classroom trials (Graham, Harris, & Zito, in press; Harris, Graham, & Mason, in press), and strategies instruction conducted by both regular and special education teachers (Graham, in press; Harris, Graham, & Adkins, 2004).

The major goals of SRSD are threefold: (a) assist students in developing knowledge about writing and powerful skills and strategies involved in the writing process, including planning, writing, revising, and editing, (b) support students in the ongoing development of the abilities needed to monitor and manage their own writing, and (c) promote children's development of positive attitudes and motivation about writing and themselves as writers. While current models of strategies instruction have converged in many ways (Pressley & Harris, 2001), in the early years SRSD differed from other strategies instruction models in at least three important ways.

First, based in part on the research on expertise in writing and research on children's self-regulation (cf. Harris & Graham, 1992), explicit instruction in and supported development of self-regulation were integrated throughout the stages of instruction in the SRSD model. Second, progression through SRSD instructional stages is criterion-based rather than time-based, so that students have the time they need to attain important outcomes. Third, struggling learners often face additional challenges related to reciprocal relations among academic failure, self-doubts, learned helplessness, low self-efficacy, maladaptive attributions, unrealistic pretask expectancies, and low motivation and engagement in academic areas. Thus, children's attitudes and beliefs about themselves as writers and the strategies instruction they participate in became critical targets for intervention as well as assessment during and after strategies instruction. Throughout SRSD instruction, students are supported in the development of attributions for effort and the use of powerful writing strategies, knowledge of writing genres, self-efficacy, and high levels of engagement (Harris & Graham, 1992).

There has been SRSD research with respect to a variety of genres, including personal narratives, story writing, persuasive essays, report writing, expository essays, and state writing tests. SRSD produces significant and meaningful improvements in children's development of planning and revising strategies, including brainstorming, self-monitoring, reading for information and semantic webbing, generating and organizing writing content, advanced planning and dictation, revising with peers, and revising for both substance and mechanics (Graham & Harris, 2003).

SRSD has resulted in improvements in four main aspects of students' performance: quality of writing; knowledge of writing; approach to writing; and self-efficacy, effort, or motivation (Graham, in press; Graham & Harris, 2003). Across a variety of strategies and genres, the quality, length, and structure of students' compositions have improved. Depending on the strategy taught, improvements have been documented in planning, revising, content, and mechanics. These improvements have been consistently maintained for the majority of students over time, with some students needing booster sessions for long-term maintenance. SRSD students have generalized writing strategies across settings, persons, and writing media. That SRSD improves the writing of both normally achieving students as well as students with LD makes it a good fit for inclusive classrooms.

Meta-analyses of strategies instruction in writing. Recently, two meta-analyses of research in writing strategies instruction have been reported. The first focused on the SRSD model (Graham & Harris, 2003). The second encompassed all empirical research in writing strategies instruction that met established criteria, including both group comparisons (including experiments involving random assignment to treatments and quasi-experimental designs) and single subject design studies from grades 1–12 (Graham, in press).

Thirty-nine studies are included in Graham's (in press) meta-analysis: 20 involving group comparisons and 19 using single subject design. Writing strategy instruction proved effective across diverse measures of writing performance. The mean effect size immediately following strategy instruction in 20 group comparison studies was 1.15, with effect sizes at posttest for key measures (writing quality, elements, length, and revisions) of 1.21, 1.89, .95, and .90, respectively. The effect size for mechanics was relatively weak, .30, at posttest. The effect sizes calculated for the single subject design studies were similar. Graham placed these effect sizes in perspective by noting that the most successful intervention (the environmental model) in Hillock's (1984) meta-analysis of different methods for teaching writing has an average effect size of .44. SRSD is clearly powerful relative to alternatives.

Graham (in press) also found that while maintenance was assessed in only 54 percent of the studies reviewed and generalization in only 38 percent of studies, effect sizes were large here as well. For example, in the group comparison studies, maintenance, generalization to genre, and generalization to setting/person effect sizes were 1.32, 1.13, .93, respectively. These were not related to the type of student receiving instruction, grade-level, strategy taught, or genre. Finally, while it has been suggested that teachers may not be able to realize effects as strong as those obtained by researchers and research assistants delivering interventions, there was no statistically significant difference between type of teacher in the group comparison studies, and teachers obtained larger effects than graduate assistants/researchers in the single subject design studies reviewed.

Finally, Graham (in press) noted that studies using the SRSD model accounted for 45 percent of the group comparison studies and 68 percent of the single subject design studies. The average effect size for SRSD studies was almost twice that of the other studies. The three characteristics of SRSD noted previously might explain this: There is explicit development of self-regulation strategies in tandem with writing strategies; instruction is criterion-based rather than time-based, and such instruction explicitly targets attitudes, beliefs, and motivation.

Much more remains to be learned about writing strategies instruction and the SRSD model. SRSD continues to evolve. Mason (2004) is now studying the effects of SRSD on multiple measures of both expository reading comprehension and expository writing among fifth-grade students who struggle with reading and writing. The instruction is being studied with both special education and general education teachers, with the reading and writing part of science and social studies instruction (i.e., there are strong cross-curricular connections).

Foreign Language Learning[1]

There has been considerable advance in understanding the nature of second language acquisition in the past half century, with much of the work carried out and interpreted within information processing theory (McLaughlin & Heredia, 1996). Teaching second languages in school is challenging. Contrary to some early hypotheses that children are especially adept at second language acquisition, in fact, the younger the child, the greater the challenge in learning a second language. Acquiring a second language is definitely a long-term developmental process.

Well before educational psychologists conceived of good information processors, foreign language educators advanced the idea of good language learners (Rubin, 1979), with this conception of language learning definitely consistent with most aspects of the good information processing perspective. Good second language learners are very strategic. For example, they habitually make informed guesses about the meanings of words and phrases they encounter, making inferences about possible meanings based on context clues. When good language learners do not know exactly how to say something in the second language, they creatively use what they do know about the language to attempt to express meaning, often adapting the rules of the language. They learn strategies for keeping conversations going and approaches that work to keep them in a conversation even if they cannot quite say what they mean. Good language learners use a variety of memory strategies to remember the meanings of words encountered, including mnemonic systems, such as the keyword method, discussed previously in this chapter. They learn "chunks" of language and pay attention to idioms and proverbs, which can be learned as wholes. The good language learner pays attention to meaning, habitually making the most of context clues (e.g., speaker gestures) to guess at the meaning of a word or phrase.

Such attention to context clues permits the development of sophisticated metacognitive competence, with the good language learner aware of when and where to use particular aspects of the language being learned (e.g., when and how to speak formally versus informally). Indeed, the good language learner actively and consciously monitors her or his language and the effects it has, gaining insights about the language by doing so. Further, the good language learner is motivated to learn the second language, wanting to learn how to communicate well in the second language. In short, good language learning is self-motivated and self-regulated. The good language learner knows and uses a variety of strategies, improving as a result of practice and reflection on the language during attempts to understand and communicate with the language. Thus, good language learners develop ever greater strategic, metacognitive, and other knowledge about language (e.g., vocabulary).

Considerable evidence supports of the major tenet that good second language learners are considerably more strategic than weaker second language learners (O'Malley & Chamot, 1990). There is growing evidence that among K–12 students, good second language learners are more sophisticated in their use of strategies than weaker second language learners, with some of the most compelling work consisting of analyses of verbal protocols of language learning (i.e., think-alouds as students attempt foreign language tasks; e.g., Vandergrift, 2003). Thus, employing verbal protocol analyses to document strategy use, Chamot and El-Dinary (1999) found that better child language learners used more of some strategies than weaker learners when they read in the second language. Stronger students made more predictions, inferences, and elaborations based on background knowledge, whereas the weaker students expended more effort on sounding out strategies (i.e., the stronger students attempted more to process the text meaningfully whereas the weaker students were still struggling with simply reading the words).

Research supports the remaining tenets as well. Good language learners monitor their learning and use of language more than weaker learners (Chamot, 1999; Chamot & El-Dinary, 1999). Better students also are more likely to relate aspects of the second language to prior knowledge than weaker students, for example, using cognates to make inferences about the meanings of words in the second language (O'Malley, Chamot, & Kupper, 1989). Even when good and poor learners use the same number of strategies, the good learners are more likely to use task appropriate strategies, probably caused by greater metacognitive understandings about when and where particular strategies should be used (e.g., Chamot, Dale, O'Malley, & Spanos, 1993; Chamot & El-Dinary, 1999; Vann & Abraham, 1990). Better second language learners do more cognitive and metacognitive processing—much of it strategic processing—than do less skilled second language learners (Vandergrits, 2003).

Are good language learners good at language learning because they use strategies? An answer to that question could only follow from experimental studies. The most complete experimentally evaluated foreign language learning strategy is the keyword method, which generally improves learning of associations between second language vocabulary items and their definitions (see Pressley, Levin, & Delaney, 1982, for a review). The keyword method involves identifying part of the foreign word that sounds like a familiar word in the first language (e.g., for the Spanish word, *pato*, *pot* might serve as a keyword). Then, learners either construct (i.e., make a mental image) or look at a picture depicting the keyword and definition referent in interaction (e.g., an image of a *duck* with a *pot* on its head). Work on the keyword method for learning foreign vocabulary is continuing (Zhang & Schumm, 2000), stimulated in part by concerns that the method does not facilitate learning of the foreign word as completely and reliably as other approaches and concerns that the keyword method produces only short-term memory advantage for foreign word-definition associations (Carney & Levin, 1998; Gruneberg, 1998; Lawson & Hogben, 1998; Nikol, Levin, & Woodward, 2003; Wang & Thomas, 1995, 1999). In general, however, there is at best mixed support for these points of concern, although we anticipate that research will continue to document the boundary conditions on keyword method efficacy.

Although other single second-language learning strategies have not been validated in true experiments as extensively as the keyword method, in a few studies (Cohen, 1998; Thompson & Rubin, 1996), second-language education researchers have evaluated the effects of teaching students a large repertoire of strategies appropriate for a range of second language goals (e.g., learning second-language vocabulary, comprehending text in a second language, composing in the second language). The results in these studies have been mixed, although at least slightly more positive than negative. Even so, we expect more such work in the future, with Chamot and O'Malley (e.g., 1996) offering powerful justification for providing broadly applicable strategies instruction to students learning a second language for use in school (i.e., instruction in how to tackle academic content and tasks as well as strategies for second language acquisition). Although research on the consequences of teaching such strategies is not as far along as in other academic arenas, there has been enough evidence of improved second language learning following strategies instruction to encourage continued research on this topic.

Mathematical Problem Solving

Mathematical problem-solving is being intensely researched at present, by a wide variety of investigators, from basic cognitive scientists to educational psychologists to mathematics educators and curriculum developers. Much has been learned about how children solve mathematical problems and how they can learn to solve them through instruction, with strategies instruction proving a potent contributor to advancing children's mathematical competencies.

Researchers interested in basic cognitive development have devoted considerable attention in the past two decades to determining whether young children (i.e., preschoolers to children in the primary grades) use strategies when they solve simple problems, most prominently simple arithmetic fact problems (e.g., $5 + 4 = ?$). By carefully observing young children attempting to solve such problems, studying their reaction times (i.e., how long it takes to produce answers to such problems), and studying their patterns of errors, researchers have come to understand that even preschoolers and kindergarten children are sometimes strategic (e.g., counting on their fingers to solve a math fact problem, counting up from the larger addend). With advancing age and practice with particular problems, children come to know the answer without having to do the computation, so that with advancing age/grade basic fact problem-solving is less mediated by strategic computation and more simply retrieval of information from long-term memory (Barrouillet & Fayol, 1998; Siegler, 1996). Even some adults, however, occasionally rely on mathematical computation over fact retrieval for simple arithmetic (Hecht, 2002).

Many cognitive developmentalists believe that children discover the strategies they use to solve such simple math problems, including discovering that after awhile they do not have to do the computation but can rely on the answer they know from previous problem-solving trials, although some children will do the computation just to make certain (see Siegler, 1996, for a review). That young children use strategies to do math fact problems with developmental shifts in strategies use is consistent with a great deal of research establishing that, with increasing age and education, students exhibit more use of strategies and more use of powerful strategies increasingly better matched to the problems being tackled, with this holding for a wide variety of problem types (e.g., Carpenter, Franke, Jacobs, Fennema, & Empson, 1998; Christou & Phillipou, 1998; Dixon & Moore, 1996). How much of such development represents strategy discovery and how much is due to instruction, however, is impossible to discern in these studies.

Although children do discover strategies some of the time, problem-solving strategies instruction is often needed. Indeed, there is a long history of strategy instruction being at the heart of developing mathematical problem-solving skills. One of the most famous books in the field of mathematics education is Polya's (1957), *How to Solve It*. Polya advocated that students attack problems using four general strategies: (a) The problem solver first should attempt to understand the problem as completely as possible. This can be accomplished by identifying and reflecting on information in the problem. This is decidedly reflective activity.

Rather than starting to compute an answer when first encountering a number in a problem, the good problem solver reads the entire problem and reflects on the meanings of the numbers in it and the other relationships specified in the problem. (b) The problem solver devices a plan for solving the problem, relying somewhat on prior knowledge to do so. For example, good problem solvers try to determine whether this problem is similar to previous problems encountered and whether solutions that worked with previous problems might be applied here. (c) The problem solver attempts to carry out the problem solving plan. (d) The problem solver checks the solution and reflects on the solution plan, perhaps trying to get the same result using a different approach. As part of such reflection, the good problem solver notes the key features of the problem and the solution plan, recognizing that similar problems might occur in the future.

In general, there has been good empirical support for Polya's position. When Burkell, Schneider, and Pressley (1990) analyzed successful problem-solving instruction with children, they found that such instruction included steps to increase understanding of problems, careful planning of solutions, carrying out solutions, and monitoring problem-solving attempts. When Hembree (1992) examined the full range of studies that evaluated Polya's approach, he found that the impact of such instruction varied with age/grade. Such teaching tended to have a small impact in the elementary grades but a large impact during high school, with the impact in college students moderately sized. That said, there are prominent research demonstrations that long-term, thorough mathematical problem-solving strategies instruction produces clear improvements in performance by the late elementary grades, even among struggling math students (e.g., Charles & Lester, 1984; Mastropieri, Scruggs, & Shiah, 1991; Montague & Bos, 1986).

More recently, there has been successful problem-solving strategies instruction in the early elementary grades, documented in well-designed studies. In Fuchs et al. (2003a, 2003b; see also Fuchs & Fuchs, 2003, for a review), grade 3 students were provided strategies to solve particular types of problems. Fuchs and Fuchs embellished such instruction with metacognitive information, specifically teaching the students that the strategies they were learning could transfer and giving them information about how superficially different problems can have the same underlying structure. The students had opportunities to practice the strategies they learned with a variety of such superficially transformed problems. In their most extensive treatment condition, the grade 3 students were also taught to use the strategies in a self-regulated fashion. Thus, they were instructed to check to see if their answers made sense and always to recheck their computations. In checking problems, there was emphasis both on getting the answer correct and using the strategies taught appropriately and completely. Students engaged in such reflection both when doing problems in class and as homework. The bottom line in their work is that grade-3 students, even average and weaker problem solvers, in fact, learned the strategies and transferred them appropriately, with each strategy taught and practiced over 1 to 2 weeks. Nonetheless, there was room for additional transfer in their studies; the type of elaborated problem-solving strategies instruction that the Fuchs studied deserves broader research attention.

In general, Polya's approach is consistent with the good information processing perspective, although subsequent models of mathematical cognition and problem-solving were more comprehensively consistent. Thus, Schoenfeld (1992) and Pressley (1986) both dealt with the role of prior knowledge and motivation in problem-solving much more explicitly than did Polya. An important development in the past decade and a half has been K–12 mathematical curricula that stress student understanding of mathematics, the development of strategic competence, and instruction that is motivating because it encourages student exploration and reflection—that is, curricula that are broadly consistent with Polya's framework. An important characteristic of recently developed curricula emphasizing understanding is that they are engaging curricula (Henningsen & Stein, 1997). Problems are presented in interesting ways and connections between the math they are learning and the worlds they experience and care about are made clear to students. Efforts are made to provide tasks that are challenging but not so far beyond students' current understandings to be impossible. Teachers scaffold student attempts at problem-solving, providing hints and supports as needed for the student to make progress in problem-solving. Students are given enough time to explore, understand, and solve problems. These are environments that emphasize learning rather than grading and competition for grades (e.g., Anderman et al., 2001).

A number of such curricula have been studied in well-designed comparative studies (i.e., the curricula emphasizing understanding have been compared with more conventional curricula, which involve more direct teaching of formula and routines). In general, such curricula have fared very well in such comparisons, with student mathematical achievement generally higher when understanding, reflection, and teacher-assisted discovery of strategies is emphasized (e.g., Boalar, 1998; Carroll, 1997; Cramer, Post, & delMas, 2002; Fuson, Carroll, & Drueck, 2000; Hollar & Norwood, 1999; Huntley, 2000; McCaffrey, Hamilton, Stecher, Klein, & Robyn, 2001; Reys, Reys, Lapan, Holliday, & Wasman, 2003; Riordan & Noyce, 2001; Thompson & Senk, 2001).

Although there is evidence that children can and do invent basic arithmetic problem-solving strategies, there is substantial evidence that teaching problem-solving strategies improves math achievement. Successful math instruction targets the development of strategies for understanding problems, strategies for solving problems, metacognitive understandings about when and where to use particular strategies, and how much strategies can be appropriately adapted and transferred, as well as motivation to do mathematics. We expect work on cognitive strategies instruction in math to continue, but probably more as part of multi-component instructional packages attempting to develop the strategies, knowledge, and understanding that excellent problem solvers use. Far more analytical research on these packages is needed, for these packages are at the center of contemporary mathematics reform efforts.

DISCUSSION

The focus in this chapter has been on students in K–12, for most work on strategies instruction has occurred with those students. There is now great interest, however, in studying strategies instruction in post-secondary education. We refer interested readers to Butler (e.g., Butler, Elaschuk, & Poole, 2000; Wong et al., 2003), an emerging leader in the application of strategies instruction in post-secondary settings. Thus, academic strategies instruction has the potential to impact a variety of content areas and diverse students. Butler's work and the work of many others studying cognitive strategies instruction in academic domains was informed by the basic research reviewed early in this chapter. We believe that cognitive strategies instruction research and practice is most likely to thrive if there is high awareness of the historic work and substantial reflection on why academic strategies instruction works well when it works well; models such as transactional strategies instruction and SRSD were clearly designed to include components with proven potency in the basic strategies instructional literature.

Basic theory and research on strategies instruction, mostly carried out in the 1960s through the 1980s, set the stage for researchers interested in curricular issues to begin teaching strategies in reading, writing, second language learning, and mathematical problem-solving. This basic research was very analytical, which was possible because it was conducted with relatively simple tasks (as compared to all that is involved in reading, writing, second language acquisition, and math problem solving) and simple strategies, often ones that could be taught in a few minutes. Far more analytical research is needed in addressing the multicomponent strategies instruction models evolving now is needed. One explanation for the lack of a correspondingly analytical literature with respect to strategies instruction in the curriculum is the huge difference in the complexities of the situations studied by the basic scientists interested in strategies and the applied researchers interested in moving strategies instruction into school settings.

One of the most important concepts emerging from the basic strategies instructional literature was that of production deficiency: People can often be taught to use strategies they do not use on their own. There were many examples of production deficiencies covered in this chapter. Young learners who do not use reading, writing, second language, and math problem solving strategies often can be taught to use them with benefit, although the instruction can be complex and long term.

A second important insight emerging from the basic strategies instruction literature was that maintenance and transfer of learned strategies requires instruction that includes metacognitive information and self-regulated use of the strategies being taught. Two bodies of research covered in this chapter have established that state-of-the-art/science strategy instruction is metacognitively rich and does demand self-regulated student use. The first is contemporary comprehension strategies instruction, as conceptualized in the transactional strategies instruction model. Extensive qualitative data documenting what goes on in such classrooms (e.g., Pressley, El-Dinary, et al., 1992) have documented the characteristics of this approach. The second is SRSD for writing (Graham & Harris, 2003) where the model has been presented in detail and studies have included assessment of whether the instructional model was followed as intended. Although such complete instruction probably occurs at least some of the time with respect to word recognition strategies instruction, second language strategies instruction, and mathematical problem-solving strategies teaching, the literature we reviewed did not include complete enough analyses to be certain. For example, although there have been many experimental studies of phonics instruction (i.e., teaching students to use phonics strategies), we cannot locate any analyses of all that goes on during effective phonics instruction. The National Reading Panel (2000) applauded the many experimental evaluations of phonics instruction, but we point out here that phonics researchers have not provided research that makes clear just how phonics should be taught—that is, how students can be motivated to do phonics, how critical metacognitive information can be highlighted, and how such instruction mixes with other aspects of the language arts morning. Thus, we urge both more experimental evaluations of most forms of strategies instruction but also qualitative analyses that make clear how such instruction can be done well.

Basic researchers were also interested in determining who could learn strategies and who could not. Thus, one hypothesis was that learning some capacity-demanding strategies requires substantial short-term/working memory, with at least some evidence generated to support that perspective (Cariglia-Bull & Pressley, 1990; Pressley et al., 1987). There has not been corresponding attention to short-term/working memory constraints in analyzing applied strategies instruction, with many of the curricular strategies reviewed in this chapter highly demanding of short-term capacity, or so it seems to us as we reflect on what learners must do to execute them. We think that there should be attention to the issue of whether working memory capacity differences make a difference in whether students can learn a variety of strategies, noting that such work would be consistent with indications in the literature that short-term/working memory differences matter in academic learning (e.g., for reading, see Cain, Oakhill, & Bryant, 2004; for writing, see Butterfield, Hacker, & Albertson, 1996; Hoskyn & Swanson, 2003).

A more general point is that the basic strategies researchers were much more attentive to when participants could not learn or would not use strategies. There has been much less attention to this in the applied strategies instructional arena. We urge applied strategies instructional researchers to study carefully concepts like mediational and utilization deficiencies to determine whether such processes might be helpful in understanding when some students do not benefit as much from strategies instruction as others.

Are we anywhere near to understanding academic strategies use the way that we seem to understand strategies use by skilled baseball managers? The answer is that we are getting there. Future research is needed to address the complexities and subtleties inherent in such understanding. We note that one methodology has been more illuminating than any other with respect to the complex strategies used by the academically competent versus those who struggle with learning—verbal protocol analysis (Ericsson & Simon, 1993). We encountered many verbal protocol analyses as we reviewed this literature. This methodology allows documenting use of conscious cognitive processing (Pressley & Hilden, in press-b), documenting the complex orchestration of strategies by skilled learners and the less complete orchestration of processing by less skilled learners.

Such work is decidedly qualitative rather than experimental, and we note that far more qualitative research is needed to further our understandings of strategies and strategies instruction. Excellent programs of research on strategies instruction have been, and will continue to be, characterized by qualitative studies to generate descriptive understandings of students' use of strategies, as well as by experimentation to validate that the cognitive strategies reported by effective learners can be successfully taught to those who experience difficulties. We are confident that there will be much more programmatic study of strategies use and strategies instruction in the years and decades ahead.

It is clear that successful academic performance in each of the domains we have addressed requires many specific strategies for the many different types of tasks and challenges encountered from preschool through high school. As there are numerous specific strategies for students to learn, the development of strategic competence must be conceived as a long-term venture. Developmental research is clearly needed. Finally, such development through instruction cannot occur unless teachers receive the support needed to move strategies instruction from research to practice. We hope the research community will rise to the challenge of developing and investigating professional development approaches that will make this possible.

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