CHAPTER 5

Metacognition and Learning

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METACOGNITION: IN SEARCH OF A DEFINITION

A useful convention for beginning a chapter on any topic is to define that topic clearly. An unambiguous definition assures the establishment of clear communication pathways between the writer and the audience. That makes it obvious from the outset what the chapter will and will not be about. Unfortunately, this is not an easy task for a chapter about metacognition. This entire chapter could focus solely on an attempt to reconcile what researchers, teacher-educators, and practicing educators mean when they use this term. One deceptively simple definition, "thinking about thinking," is really very complicated as evident from the blank stares I receive when I present that definition to a roomful of preservice teachers. Because the title of this chapter is "Metacognition and Learning," I decided to attempt to define metacognition as succinctly as I can and then move on to a discussion of research on the role of metacognition in classroom learning. I begin with a presentation of more basic research on metacognition, followed by a summary of research on three classroom skills: reading, writing, and problem solving. Finally, I review research on classroom interventions designed to facilitate the development of metacognition.

Metacognition emerged as an explicit focus of research in psychology (with an initial focus on metamemory) in the early 1970s, but psychologists and educators have long been aware of the knowledge and skills encompassed by this term (Baker & Brown, 1984). John Flavell (1976) offered an early commonly accepted definition of metacognition as "knowledge concerning one’s own cognitive processes and products or anything related to them" (p. 232). More than a decade later, Paris and Winograd (1990) asserted that most theorists emphasize two aspects of metacognition, knowledge about cognition and control over cognition.

Knowledge Versus Control Distinction

Metacognitive knowledge is typically characterized as being comparatively stable and usually storable (Baker & Brown, 1984; Garner, 1987). Jacobs and Paris (1987) further delineated the knowledge component of metacognition into declarative, procedural, and conditional aspects of knowledge.
Declarative metacognitive knowledge refers to knowledge that a person may have about his or her abilities and about the salient learning characteristics that affect cognitive processing. Learners vary in the quality of their declarative knowledge depending on a variety of factors including age and ability. Flavell (1979) distinguished between types of declarative knowledge along the dimensions of knowledge of person, task, and strategy. Procedural metacognitive knowledge refers to knowledge of how to execute procedures such as learning strategies. The procedural knowledge of skilled learners is more automatic, accurate, and effective than that of unskilled learners. Conditional metacognitive knowledge refers to knowledge about when and why to use procedures or strategies. The conditional knowledge of successful learners makes them very flexible and functional in their strategy use.

Metacognitive control, sometimes also referred to as executive control, is described in various ways by different researchers, but the similarity among the definitions is fairly evident. Jacobs and Paris (1987) demarcated metacognitive control into the processes of planning, evaluation, and regulation. Planning includes the selection of a strategy to achieve a goal. Evaluation is monitoring of the progress made toward achieving the goal. Regulation refers to the revision or modification of the strategies to achieve the goal. Hacker (1998a) described executive control as consisting of both monitoring and regulating. Monitoring includes identifying the task, checking the progress of task completion, and predicting the eventual outcome. Regulation includes allocation of resources, specifying the number of steps to complete a task, and the intensity and speed with which it will be completed. Paris and Lindauer (1982) described metacognitive control during reading and writing as consisting of planning, monitoring, and evaluation. In this case, planning refers to the selection of strategies and the allocation of resources, monitoring to comprehension monitoring, and evaluation to the examination of progress toward goals that can lead back to more planning and more monitoring. What is common to all of these articulations of the control process is some initial analysis of what to do, making a plan to do something, evaluating the usefulness of that plan, and then making appropriate revisions or modifications to the original plan.

Garner (1987) described boundaries between research on metacognition and research on executive control. These areas of research have developed from different theoretical orientations, make dissimilar assumptions, and rely on diverse methodological tools. Much of the work on metacognition emerged from Piagetian developmental research, whereas research on executive control originated in the information-processing model. Researchers from the two traditions differ in the emphasis placed on metacognitive knowledge rather than metacognitive control.

Alternative Perspectives

There are, however, alternative perspectives on metacognition. For example, Schraw and Moshman (1995) focused on learners’ theories about their own cognition and how well developed these knowledge structures are. These theories are “systematic frameworks used to explain and direct cognition, metacognitive knowledge, and regulatory skills” (p. 351). Schraw and Moshman distinguished between tacit, informal, and formal metacognitive theories. Tacit theories are implicit, “acquired or constructed without any explicit awareness” (p. 358). Because learners are not aware of them, these implicit frameworks are not accessible for verification and may persist even when incorrect or maladaptive. Informal theories are fragmentary. Learners are aware of some of their beliefs and assumptions but “have not yet constructed an explicit theoretical structure that integrates and justifies these beliefs” (p. 359). Unlike tacit theorists, however, informal theorists do have some degree of explicit metacognition and thus can judge the value of their framework. Formal theories are “highly systematized accounts of phenomenon involving explicit theoretical structures” (p. 361). According to Schraw and Moshman, the Good Strategy User as outlined by Pressley, Borkowski, and Schneider (1987) would be an example of a formal metacognitive theory. Formal theorists are explicitly aware of their “purposive efforts to construct and modify metacognitive theories” (Schraw & Moshman, 1995, p. 361), so they can use formal theory to assess and interpret observations. Schraw and Moshman suggested that learners develop metacognitive theories through cultural learning, individual construction, and peer interaction. Cornoldi (1998) echoed the perspective of Schraw and Moshman in his definition of metacognitive attitude as the “general tendency of a person to develop reflection about the nature of his or her own cognitive ability and to think about the possibility of extending and using this reflection” (p. 144).

Critical Distinctions

Sometimes in order to get a more focused view of what something is, theorists and researchers try to elucidate what it is not—a nonexample using the terminology of the concept-learning literature. One key discrimination for understanding the concept of metacognition is to articulate the distinction between cognition and metacognition (Nelson, 1999; Nelson & Narens, 1994). Nelson (1999) defined metacognition as “the scientific study of an individual’s cognitions about his or her own cognitions” (p. 625). Thus, metacognition is a subset of cognition, a particular kind of cognition. Garner and Alexander (1989) identified cognitive strategies as activities
for cognitive enhancement and metacognitive strategies as activities for monitoring cognitive processes. In other words, cognitive skills facilitate task achievement, and metacognitive skills help to regulate task achievement. Some research has supported the distinction between cognition and metacognition. For example, there is evidence that metamemory deficits can exist without memory impairment, so memory and metamemory are distinct (Nelson, 1999). Swanson (1990) provided evidence for the independence of metacognition from general aptitude by finding that fifth- and sixth-grade students with high levels of metacognitive skill outperformed students with low levels of metacognitive skills on problem-solving tasks regardless of overall aptitude. Although Hacker (1998a) referred to the “debatable issue” of whether thoughts that were initially metacognitive but are now nonconscious and automatic can still be considered metacognition (see also Nelson, 1996), he suggested that most researchers consider metacognitive thought to be conscious and purposeful thinking (about thinking). Paris and Winograd (1990) limited their conception of metacognition to “knowledge about cognitive states and abilities that can be shared among people” (p. 21).

Another important distinction is that between metacognition and self-regulation. Paris and Winograd (1990) noted that some researchers also include an affective component in their definitions of metacognition such as metacognitive beliefs or attributions. Borkowski (1996), for example, described three interrelated aspects of metacognition: knowledge, judgments and monitoring, and self-regulation. Borkowski’s view of metacognitive knowledge corresponds to Flavell’s (1979) categories of person, task, and strategy. Judgments and monitoring refer to processes occurring while performing a task, such as a feeling of knowing or comprehension monitoring. Self-regulation refers to adapting skills and strategies to meet changing demands. Zimmerman (1995), however, argued that self-regulation “involves more than metacognitive knowledge and skill, it involves an underlying sense of self-efficacy and personal agency and the motivational and behavioral processes to put these self beliefs into effect” (p. 217). A learner could have well-developed metacognitive knowledge but be unable to self-regulate in a specific context. Self-regulated learning refers to the “capability to mobilize, direct, and sustain one’s instructional efforts” (p. 217). Thus, self-regulated learning is “more than metacognitive knowledge and skill, it involves a sense of personal agency to regulate other sources of personal influence (e.g., emotional processes and behavioral and social-environmental sources of influence)” (p. 218; for a further discussion of self-regulated learning, see chapter by Schunk and Zimmerman in this volume).

Relevance to Cognitive Development, Expertise, and Intelligence

How does the concept of metacognition fit into theories of cognitive development? Although the basic idea of metacognition, “thinking about thinking,” has been traditionally associated with Piaget’s stage of formal operations, the concept has relevance for other theoretical perspectives in cognitive development (Yussen, 1985). The centrality of metacognition to cognitive development was highlighted by Flavell in 1979 when he argued that the “nature and development of metacognition and of cognitive monitoring/regulation is currently emerging as an interesting and promising new area of investigation” (p. 906). He described young children as being limited in their knowledge about cognitive phenomena (metacognition) and as failing to monitor memory and comprehension. He developed a model of cognitive monitoring that he hoped would serve as a target for development. According to this model, development occurs through interactions among metacognitive knowledge, metacognitive experiences, goals (or tasks), and actions (or strategies). Metacognitive knowledge is stored knowledge about person, task, and strategy variables. Metacognitive experiences are the “items of metacognitive knowledge that have entered consciousness” (p. 908). Through metacognitive experiences, the stored metacognitive knowledge can be altered by adding, deleting, or revising information. Paris and Winograd (1990) elaborated on the integral role of metacognition in cognitive development by arguing that metacognition is “both a product and producer of cognitive development” (p. 19).

Kuhn (1999, 2000) extended the discussion of the role of metacognition in cognitive development by focusing on the link between metacognition and the development of higher order thinking skills. She characterized the skills that most consider to be critical thinking skills as being metacognitive rather than cognitive. Higher order thinking or critical thinking by definition involves reflecting on what is known and how that knowledge can be verified—clearly metacognitive processes. Kuhn talked about metaknowing in three broad categories: metacognitive, metastrategic, and epistemological. Metacognitive knowing is declarative knowledge, knowledge about cognition. Metastrategic knowing refers to the selection and monitoring of strategies (procedural knowledge). Epistemological knowledge refers to the general philosophical questions underlying a thoughtful examination of knowledge itself.

What is the role of metacognition in the development of expertise? Experts differ from novices in a variety of ways, some of which are metacognitive. They are more skilled than novices at time allocation, strategy selection, prediction of task difficulty, and monitoring (Sternberg, 2001). Ertmer and
Newby (1996) presented a model of expertise, describing experts as strategic, self-regulated, and reflective. They argued that the key to developing expertise is the facilitation of the growth of reflection. Kruger and Dunning (1999) demonstrated that college-aged novices possess poorer metacognition than college-aged experts in three different domains of expertise: humor, logical reasoning, and grammar. When learners are incompetent in a domain (as indicated by making poor choices and reaching invalid conclusions), this incompetence robs them even of the ability to recognize their faulty thinking. Thus, these novices were unskilled and unaware of it. Ironically, in this study the highly competent tended to underestimate how well they had performed.

What is the relationship of metacognition to "intelligence"? Metacognition is a key component in at least one theory of intelligence—Sternberg’s Triarchic Theory (1985). The triarchic theory is composed of three subtheories: contextual, experiential, and componential. The contextual subtheory highlights the sociocultural context of an individual’s life. The experiential subtheory emphasizes the role of experience in intelligent behavior. The componential subtheory specifies the mental structures that underlie intelligent behavior. These are broken down into metacompontents, performance components, and knowledge-acquisition components. The metacompontents described by Sternberg include primary metacognitive processes such as planning and monitoring (see also chapter by Sternberg in this volume for an analysis of contemporary theories of intelligence).

Is metacognition a domain-general or a domain-specific skill? Research on expertise often emphasizes domain specificity, whereas theories of intelligence imply a generalized skill. Schraw, Dunkle, Bendixen, and Roedel (1995) explored the generality of monitoring by comparing correlations and principal component structures among multiple tests with four different criterion measures. Their findings provided qualified support for the domain-general hypothesis. Schraw and Nietsfeld (1998), however, concluded that there may be separate general monitoring skills for tasks requiring fluid and crystallized reasoning, and Schraw and Moshman (1995) suggested that informal metacognitive theories likely begin tied to a specific domain. More recently, Kelemen, Frost, and Weaver (2000) compared the performance of college students across a number of different metacognitive tasks. Their results indicated that individual differences in memory and confidence were stable across both sessions and tasks but that differences in metacognitive accuracy were not.

Summary

In 1981 Flavell characterized metacognition as a “fuzzy concept” (p. 37). It is not certain that work in this area has greatly reduced this fuzziness in the two decades that have elapsed since his paper was published. The boundaries between what is metacognitive and what is not are not clearly defined. Hacker (1998a) declared that this field of investigation is “made even fuzzier by a ballooning corpus of research that has come from researchers of widely varying disciplines and for widely varying purposes” (p. 2). Borkowski (1996) described the theoretical work on metacognition as “weakly related mini-theories, whose boundary conditions are so poorly delineated that any attempt at empirical and/or theoretical synthesis is nearly impossible” (p. 400).

When I teach introductory educational psychology classes, I am confronted with the problem of conveying the complex concept of metacognition to students planning to become teachers. What ideas will be useful to them in their current roles as students? What can they take with them into the classroom in their future roles as teachers? How can we reduce the “fuzziness”? What kinds of classroom skills are we talking about? What can be applied to classroom tasks from theory and research on metacognition?

What I present to my class is the following list of topics in metacognition.

- Knowing about cognition generally (“thinking about thinking”).
- Metacognition about memory.
- Metacognition about reading.
- Metacognition about writing.
- Metacognition about problem solving.
- Knowing when you do or don’t understand.
- Also known as comprehension monitoring.
- As in reading.
- Knowing how well you have learned something.
- As in studying.
- Knowing how well you have performed on a test.
- Knowing about skills and procedures you can use to improve your cognitive performance.
- Knowledge about strategies (declarative knowledge—your repertoire).
- Knowing how to use strategies (procedural knowledge—the steps).
- Knowing when to use strategies (conditional knowledge—when to use which strategy).

It would be impossible to do justice to all of these aspects of metacognition in a single chapter. Many topics within metacognition are deserving of their own chapters, as attested to by the recent publication of entire books on metacognition and educational theory and practice (Hacker, Durlosky, & Graesser, 1998; Hartman, 2001a). The remaining portions of
this chapter describe research exploring the application of metacognition to selected learning situations.

**BASIC RESEARCH ON METACOGNITION**

There is an extensive research literature exploring metacognitive processes as they occur in controlled learning situations on specific types of learning tasks. Much of this research examines basic metacognitive processes in paired-associate-type learning tasks. Although this research does have relevance to the subset of classroom learning tasks that require learning associations (e.g., vocabulary learning), it is unclear whether conclusions drawn from this research can be generalized to classroom learning tasks involving connected discourse. What follows is a brief summary of the metacognitive processes studied in this research paradigm.

Nelson (1999) described three types of prospective monitoring, that is, monitoring of future memory performance. The *ease-of-learning judgment* (EOL) refers to a judgment before study. The learner evaluates how easy or difficult an item will be to learn. For example, someone learning French vocabulary might predict that learning that “chateau” means “castle” would be easier than learning that “boite” means “box.” These EOL predictions tend to be moderately correlated with actual recall.

A second type of monitoring is assessed by a *judgment of learning* (JOL), which is a judgment during or soon after study about future recall. It is the prediction of the likelihood that an item will be remembered correctly on a future test. Typically, learners are more accurate in their JOL predictions than in their EOL predictions. One interesting finding is that if JOL is delayed (e.g., 5 min after study), the prediction is more accurate than immediate JOL (e.g., Nelson & Dunlosky, 1991). Delayed JOL is more accurate if and only if learners are provided with the cue-only prompt (in the French vocabulary example, the cue of “chateau?”) and not when provided with a cue-plus-target prompt (e.g., “chateau-castle?”).

The third type of monitoring is assessed by a *feeling of knowing* (FOK), which refers to rating the likelihood of future recognition of currently forgotten information after a recall attempt. Some studies elicit FOK for only incorrect items. Klin, Guzman, and Levine (1997) reported that FOK judgments for items that cannot be recalled are often good predictors of future recognition accuracy. This indicates that exploring more about “knowing that you don’t know” is a promising avenue for future investigations.

There is also research on retrospective confidence judgments, which are predictions that occur after a recall or recognition performance. On these tasks, there is a strong tendency for overconfidence—especially on recognition tasks (Nelson, 1999). A developmental pattern has also been observed in that with increasing age, knowledge about information available in memory becomes more accurate (Hacker, 1998a).

The body of research on monitoring of learning in these basic learning tasks is growing rapidly and contributing greatly to our understanding of basic monitoring processes. Because the focus of this chapter is on the role of metacognition in learning situations that most often occur in classrooms, we now turn to a discussion of research on metacognition and reading. Reading is arguably the cognitive skill that underlies the majority of classroom learning tasks.

**RESEARCH ON METACOGNITION AND READING SKILLS**

Pearson and Stephens (1994) summarized the contributions of the disparate fields of linguistics, psychology, and sociolinguistics to the scientific study of the processes comprising the complex task of reading. One indication of the importance of research on metacognition to this endeavor is the inclusion of metacognition as a separate category in an edited volume titled *Theoretical Models and Processes of Reading* (4th edition) published by the International Reading Association (Ruddell, Ruddell, & Singer, 1994; for a thorough treatment of literacy research, see chapter by Pressley in this volume).

Metacognition about reading is a developmental phenomenon. In an early study, Myers and Paris (1978) questioned 8- and 12-year-old children about factors influencing reading and found age-related differences in metacognitive knowledge about reading. The younger children were less sensitive to different goals of reading, to the structure of paragraphs, and to strategies that can be used to resolve comprehension failures. Knowledge of text structure also develops. Engle and Hiebert (1984) found that third and sixth graders' knowledge of expository text structure was related to age and reading ability. Although many aspects of metacognition involved in reading have been explored, unquestionably the focus of many researchers studying metacognition in reading has been on the process of monitoring comprehension.

**Comprehension Monitoring**

Much of the early research investigating comprehension monitoring employed the error detection paradigm. In this research paradigm learners are asked to read textual material that contains some kind of inconsistency or error. Whether learners notice the error is an indication of the quality of their comprehension monitoring. Adult readers typically do not
excel at comprehension monitoring as indicated by the many studies reporting failures to detect errors (for reviews, see Baker, 1989; Pressley & Ghatala, 1990). As Baker (1989) reported, “detection rates tend to average about 50% across studies” (p. 13). The likelihood with which adults may detect errors in text is influenced by a variety of factors. These include whether they were informed about the likelihood of errors being present, whether the errors were found in details or in the main point of the text, and perhaps most important, what standards they use to evaluate their comprehension (Baker, 1985, 1989).

Baker (1985) described three basic types of standards that readers use to evaluate their comprehension of text: lexical, syntactic, and semantic. The *lexical* standard focuses on the understanding of the meaning of words. The *syntactic* standard concentrates on the appropriateness of the grammar and syntax. The *semantic* standard encompasses evaluation of the meaning of the text and can be further delineated into five subcategories. The first of these is external consistency, that is, the plausibility of the text. The second, propositional cohesiveness, refers to whether adjacent propositions can be integrated for meaning. The third, structural cohesiveness, focuses on thematic relatedness of the ideas in the text. The fourth, internal consistency, refers to whether the ideas in the text are logically consistent. Finally, the fifth, informational completeness, emphasizes how thoroughly ideas are developed in the text.

Much of the research using the error detection paradigm has employed texts requiring the application of the semantic standard of internal consistency. There is considerable evidence, however, that readers differ in the ease with which they apply these standards depending on age and reading ability. For example, less able readers may rely on lexical standards but can be prompted to use other standards (Baker, 1984). The most important consideration, however, is that failure to detect an error in text may not be due to a pervasive failure to monitor comprehension as much as to the application of a different standard of comprehension than the one intended by the researcher.

There are still other explanations of why readers may fail to detect errors or inconsistencies in text (Baker, 1989; Baker & Brown, 1984; Hacker, 1998b; Winograd & Johnston, 1982). According to Grice’s Cooperativeness Principle (1975), readers normally expect that text will be complete and informative and therefore are not looking for errors, would be hesitant to criticize, and are more likely to blame themselves rather than the text for any inconsistency noted. Readers might also notice the error but continue to read, expecting a resolution of the inconsistency later in the text. They might lack the linguistic or topic knowledge to detect the error. They might make infer-

ences that allow them to construct a valid interpretation of the text that is different from the one intended by the author. In response to these criticisms of the error detection paradigm, researchers have developed other techniques for evaluating comprehension monitoring such as eye movements, adaptation of reading speed, and event changes in galvanic skin response (GSR) that may indicate some level of awareness of inconsistencies that are not otherwise reported (Baker, 1989; Baker & Brown, 1984).

**Beyond the Error Detection Paradigm**

Hacker (1998b) outlined differences in the approaches used in cognitive psychology and educational psychology to study the metacognitive processes involved in processing textual material. As we have seen, researchers trained in the field of educational psychology most often use the term *comprehension monitoring* to refer to this phenomenon. Their view of metacognition and textual processing is multidimensional, involving both evaluation and regulation. Evaluation is the monitoring of the understanding of text during reading, and regulation is the control of reading processes to resolve comprehension problems. Much of the research in this tradition has employed the error detection paradigm, but educational psychologists are moving to the study of more natural reading situations, where they look at learners’ abilities to construct meaningful representations of text.

On the other hand, researchers trained in cognitive psychology typically use terms such as *metamemory for text, calibration of comprehension, or metacomprehension* for the phenomena. They operationalize the construct by relating readers’ predictions of comprehension with actual performance on a test. If they find a high correlation, they report good calibration or metacomprehension. If they find a low correlation, they report poor calibration or metacomprehension. If learners overestimate their level of comprehension, this is termed *illusion of knowing* (Glenberg, Wilkinson, & Epstein, 1982).

Metacomprehension, as studied by those trained in this tradition, has considerable relevance for classroom learning. After reading texts assigned in school (which we would expect to be relatively error free), students need to be able to make judgments about how well they have learned the material and about how well they expect they will perform on a test. In a typical study using this paradigm, Maki and Berry (1984) asked college students to read paragraphs from an introductory psychology text. After reading each paragraph, they predicted (on a Likert-type scale), how well they would perform on a multiple-choice test. For the students who scored above the median (the better learners), the mean ratings of material
related to questions answered correctly were higher than ratings of material related to questions answered incorrectly. On the other hand, Glenberg and Epstein (1985) asked college students to rate how well they would be able to use what they learned from textual material to draw an inference. They calculated point-biserial correlations between the rating given each text and performance on that text. These correlations were not greater than 0 regardless of whether the ratings were made either immediately after reading or following delay. In this study, the only judgments more accurate than chance were postdictions (those made after responding to the inference questions). Weaver (1990) found that the correlation between rated confidence and subsequent performance on comprehension questions (the mean calibration) on an expository passage was typically near zero when only one test question was used but that prediction accuracy was higher when more questions were used per prediction. Weaver and Bryant (1995) also reported that "metamemory for text" or "calibration of comprehension" was more accurate when learners made multiple judgments (see also Schwartz & Metcalfe, 1994).

Maki (1998) discussed several different processes that are likely to be involved in these predictions. One hypothesis is that students may be relying on their judgments of domain familiarity, using their prereading familiarity with the topic to make predictions. Maki (1998), however, reported data indicating that students use more than prereading familiarity with text topics to help them make more accurate predictions. Another hypothesis is that students may base their judgments on their perceived ease of comprehension. Maki (1998), however, summarized studies comparing student ratings of their comprehension of text (ease of comprehension) versus their prediction of the amount of information they would recall (future performance). Generally, there was a stronger relationship between predictions and actual performance than between comprehension ratings and actual performance. So, explicit predictions are based on something more than just ease of comprehension. After weighing the research evidence, Maki (1998) concluded that "accurate predictions are based on aspects of learning from the text, including ease of comprehension, perceived level of learning, and perceived amount of forgetting" (p. 141).

Maki (1998) also pointed out that in the body of research on paired-associate learning, delayed predictions and delayed tests produce the highest prediction accuracy. This is the classic delayed JOL described earlier in this chapter. With text material, however, immediate predictions and immediate tests produce the greatest prediction accuracy. This is a troubling finding for educators because most classroom tasks involve delayed tests.

Maki (1998) reported that the mean gamma correlation between predictions of test performance and actual test performance across many studies emanating from her lab is .27. Is it that the metacomprehension abilities of college students are so poor, or do we need a better paradigm for studying metacomprehension? Maki argued that we need to develop a more stable and less noisy measure of metacomprehension accuracy. Alternatively, Rawson, Dunlosky, and Thiede (2000) contended that researchers need to integrate theories of metacognitive monitoring with theories of text comprehension. In this study, they asked college students to reread texts before predicting performance. Rereading was expected to facilitate the construction of a situation model of the text, leading to the creation of cues that would be more predictive of future performance. In accordance with their predictions, they found that rereading produced better metacomprehension, reporting a median gamma of .60.

Testing Effect

Pressley and Ghatala (1990) summarized a series of studies designed to see if and how tests influence students' awareness of learning from text. They found that although students can monitor during study and attempt to regulate study activity, their evaluations of their learning are not fairly accurate until after they have taken a test. They called this finding of more accurate predictions of learning after testing the testing effect. Similarly, in her review of research on metacomprehension, Maki (1998) reported that many studies indicate that predictions made after taking a test (postdictions) were more accurate than predictions preceding a test. This is called the postdiction superiority effect in the metacomprehension research literature.

Exposure to and experience with the types of questions asked can also lead to better judgments of learning. For example, Pressley, Snyder, Levin, Murray, and Ghatala (1987) found that answering adjunct questions embedded in text can improve the monitoring performance of college students. Maki (1998) summarized a group of studies indicating that whether practice tests improve prediction depends on whether performance on the practice tests is correlated with performance on the criterion measure. Moreover, practice test questions are more effective if answered following a delay after reading. More recently, Pierce and Smith (2001) reported that postdictions do not improve with successive tests. Thus, they argued that the superior postdiction effect found in their study, as well as in many other studies, is likely due to students' remembering how well they answered questions rather than increasing knowledge of tests as a result of exposure to successive tests.
Question type also influences student monitoring of learning from text. Pressley, Ghatala, Woloshyn, and Prie (1990) found that college students had more accurate perceptions of the correctness of their responses to short-answer questions than of their responses to multiple-choice questions. In this study, accuracy of monitoring was measured by whether the students choose to study more after testing. Maki (1998) suggested that true-false questions may be even less helpful to student monitoring than short answer and multiple choice questions (see also Schwartz & Metcalfe, 1994).

The type of content assessed by questions also influences the size of the testing effect. Pressley and Ghatala (1988) found that postdictions of college students were more accurate for multiple-choice questions on opposites and analogies than for multiple-choice comprehension test questions. Moreover, Pressley et al. (1990) reported that college students had greater confidence that their answers to thematic questions (rather than questions on details) were correct, even when their responses were actually wrong.

There is also evidence that the ability to benefit from the information obtained by taking a test improves with development. In a study by Pressley and Ghatala (1989), seventh and eighth graders demonstrated the testing effect, whereas younger children did not. The type of test question also influences children’s monitoring abilities. Ghatala, Levin, Foorman, and Pressley (1989) found that fourth graders overestimated their mastery of the material more on multiple-choice tests with plausible distractors than in their responses to short-answer questions.

Development of Comprehension Monitoring

Since Ellen Markman’s pioneering studies (1977, 1979) using the error detection paradigm, the poor comprehension-monitoring skills of young children have been demonstrated under varying instructions and circumstances (see Markman, 1985, for a review). For example, Markman (1977) found that although third graders noticed the inadequacy of oral instructions with minimal probing, first graders did not until they saw a demonstration or acted out the instructions themselves. Markman (1979) reported that third through sixth graders failed to notice some inconsistencies in essays that were read to them, even though probing indicated that they had the required logical capacity to detect them. Markman and Gorin (1981) found that specific instructions helped 8- and 10-year-olds find problems with texts that were read to them. They suggested that the instructions enabled the children to adjust their standards of evaluation. Baker (1984) examined children’s abilities to apply three standards of evaluation (lexical, internal consistency, and external consistency) when explicitly asked to find errors in text. In the first experiment 5-, 7-, and 9-year-old children listened to text, whereas in the second experiment 11-year-olds read the texts themselves. The older children used all three standards more effectively than the younger children, and the internal consistency standard was applied least effectively across all age groups. Baker (1984) argued that these results support the view that comprehension-monitoring skills are multidimensional rather than a unitary phenomenon.

Using an on-line measure of reading speed in addition to the traditional verbal-report error detection paradigm, Harris, Kruthof, Terwogt, and Visser (1981) found that children in two age groups (8- and 11-year-olds) read inconsistent text more slowly but that the older students were more likely to report inconsistent text. Similarly, Zabrunsky and Rattray (1986) found that both third and sixth graders read inconsistent text more slowly than other information in the text, but sixth graders were more likely to use a strategy (look back) and more likely to report errors in text.

There are also developmental differences in students’ sensitivities to text characteristics as they monitor their comprehension. For example, Bonitatibus and Beal (1996) asked second and fourth graders to read stories with two alternative interpretations. The older students were more likely to notice and report both interpretations, and the two interpretations were more likely to be noticed in narrative rather than expository prose. McCormick and Barnett (1984) asked eighth graders, 11th graders, and college students to read passages (both signaled and nonsignaled) that contained inconsistencies. The presence of text signals improved the comprehension monitoring of the college students in passages where contradictions were presented across paragraphs rather than within paragraphs. The younger students did not benefit from the text signals.

Individual difference variables may moderate the developmental differences in comprehension monitoring ability. Pratt and Wickens (1983) found that kindergartners and second graders who were more reflective were more effective detectors of referential ambiguity in text than were impulsive children. Similarly, Walczyk and Hall (1989b) reported that reflective third and fifth graders detected more inconsistencies than did impulsive children across both grade levels. By far the most frequently investigated individual difference variable has been reading ability.

As might be predicted, in studies where the comprehension monitoring of good and poor readers is compared, good readers were more skilled than poor readers. Garner (1980) found that good readers at the junior high level noticed inconsistencies in text and that the poor readers did not. In a study replicating these findings, Garner and Reis (1981) asked students of varying ages (Grade 4 through Grade 10) to read texts
that contained obstacles (questions inserted in text). The poor readers mostly failed to monitor their comprehension and mostly failed to use look backs as a strategy. Garner and Kraus (1981–82) suggested that good and poor readers approach reading with widely varying purposes that affect their comprehension monitoring. They interviewed good and poor seventh-grade readers and asked them to read narrative passages (one containing inconsistencies). In their interviews, the good comprehenders described reading as more of a meaning-getting task; the poor readers described reading as more of a decoding task. The poor readers did not detect the inconsistencies in the text. In contrast, good readers could detect inconsistencies but were better with within-sentence inconsistencies than with between-sentence inconsistencies.

Paris and Myers (1981) used multiple measures to indicate comprehension monitoring and also interpreted their results as indicating that poor readers focus more on decoding the text than on determining the meaning of text. Poor fourth-grade readers monitored difficult and inconsistent information significantly less than did good readers as indicated by self-corrections during oral reading, by directed underlining, and by study behaviors. Zabrucky and Ratner (1989) used on-line measures of monitoring along with verbal reports of inconsistencies. They found that all of the sixth-grade students in their study slowed down when reading the portion of the text with inconsistencies but that good readers were more likely to look back at the problem portion of the text and to report inconsistencies verbally. In a replication of these results comparing narrative and expository texts, Zabrucky and Ratner (1992) reported that students were more likely to look back at problems in the narrative texts than at problems in the expository text. Zabrucky and Ratner interpreted their findings as evidence of rudimentary comprehension monitoring in the poor readers even though they may tend to ignore or skip portions of text that cause them problems. Rubman and Waters (2000) were able to increase the error detection of third and sixth graders (both skilled and less skilled) by the use of storyboard construction. They argued that representing stories through storyboard construction enhanced integration of the text propositions. The effect of the storyboard construction was particularly beneficial for the less skilled readers.

Baker and Brown (1984) distinguished between reading for meaning (comprehension) and reading for remembering (studying). They argued that younger and poorer readers look at reading as a decoding process rather than as a meaning-getting process and do not monitor their comprehension as effectively as do older and better readers. Baker (1989) also suggested that there is some evidence that good readers use comprehension strategies, whereas poor readers use study strategies. Yet, those who investigate students’ study behaviors would argue that students skilled in studying techniques use complex strategies focusing on understanding. For those interested in contemporary views of studying, consult recent integrative reviews detailing metacognitive processes in studying and recent research investigating the study strategies of skilled learners (Hadwin, Winne, Stockley, Nesbit, & Woszczyna, 2001; Loranger, 1994; Pressley, Van Etten, Yokoi, Freebern, & Van Meter, 1998; Son & Metcalfe, 2000; Winne & Hadwin, 1998).

In conclusion, metacognitive processes are central to skilled reading. Although reading is perhaps the primary skill underlying classroom learning, two sets of cognitive skills—those required in writing and in problem solving—also figure prominently in classroom activities. The next section presents research on the role of metacognition in effective writing skills, followed by a section on metacognitive skills in problem solving.

**RESEARCH ON METACOGNITION AND WRITING SKILLS**

Flower and Hayes (1981) developed an influential model of the composing processes from their analyses of think-aloud protocols of expert and novice writers. The act of writing is assumed to be a goal-directed thinking process in which the writer engages in four kinds of mental processes. These mental processes are planning, translating ideas and images into words, reviewing what has been written, and monitoring the entire process. There is considerable interactivity between the four processes so that the act of writing is recursive rather than linear.

Another theoretical model that has had tremendous influence on theorists and researchers is the model of writing expertise developed by Scardamalia and Bereiter (1986; Bereiter & Scardamalia, 1987). This model describes two broad strategies of composing: knowledge telling and knowledge transforming. In knowledge telling, a strategy used more often by novice writers, what is known about a topic is presented in a paper until the supply of knowledge is exhausted. In knowledge transforming the writer consciously reworks the text—diagnosing problems, planning solutions, and monitoring the effectiveness of solutions. In both of these influential models of writing, metacognitive processes, particularly monitoring, have a primary role.

Research focusing on the role of metacognition in writing has explored both the knowledge and the control aspects of metacognition (see Sitko, 1998, for a recent review). These include knowledge of the writing process and knowledge and control of strategies for these processes, including planning,
drafting, revising, and editing. Research comparing novice and expert writers indicates that in general, expert writers are more metacognitively aware, making more decisions about planning and monitoring and evaluating more as they write. Stolarak (1994) found that when novice writers are given a model of an unfamiliar prose form to imitate, they become more reflective, evaluative, and metacognitive (more like experts) than do novices not given a model.

Englert, Raphael, Fear, and Anderson (1988) investigated the development of metacognitive knowledge about writing in children. They assessed the metacognitive knowledge of fourth and fifth graders (with learning disabilities, low-achieving, and high-achieving) with an interview composed of three vignettes. The first vignette evaluated students' knowledge and strategies related to planning and organizing information relevant to specific expository topics. The second vignette focused on the role of text structure in the editing of expository text and on the general processes of planning, drafting, and editing. The third vignette evaluated students' understanding of editing and revising skills (within text structure and generally). The students with learning disabilities differed from low-achieving and high-achieving students in that they had less knowledge of writing strategies and less knowledge of how to organize ideas. In general, metacognitive knowledge was positively correlated to the quality of texts written by the students.

Knowledge of text structure plays an important role in the development of writing skills. Englert, Stewart, and Hiiebert (1988) found that both third and sixth graders were largely insensitive to text structure. The more proficient writers, however, seemed to possess a more generalized knowledge of expository text structure. Durst (1989) demonstrated that the characteristics of the text assignment influences the metacognitive strategies used by students during writing. His analysis of the think-aloud protocols of 11th-grade students for metacognitive processes used during composing revealed much more monitoring and reflecting when students were writing analyses than when they were writing summaries.

Instruction designed to enhance students' awareness of text characteristics (e.g., the underlying structure of expository and narrative text structures) improves writing skill. Taylor and Beach (1984) taught seventh-grade students a reading study strategy focusing on expository text structure and found positive effects in terms of the quality of the students' expository writing. Likewise, Graham and Harris (1989b) found that self-instruction training focusing on a type of expository writing (argumentative essays) given to sixth-grade students with learning disabilities resulted in better writing performance and higher self-efficacy for writing essays. Instruction in narrative text structure has also proved to be beneficial. Fitzgerald and Teasley (1986) provided direct instruction of story structure to fourth graders and found a strong positive effect on the organization and quality of the students' narrative writing. Similarly, Graham and Harris (1989a) provided self-instruction training in story grammar to normally achieving fifth and sixth graders and to those with learning disabilities and found that the training improved the students' composition skills and increased their self-efficacy.

Well-developed comprehension-monitoring skills are a key part of the revision process. Writers need to monitor how well the text that they have already produced matches the text that they had intended to produce. Inconsistencies between the produced text and the intended text must be noted and then resolved in some manner. Successful comprehension monitoring during the revision process may be especially difficult for writers because they may not be appropriately evaluating the meaning conveyed by their texts because of their awareness of what they had intended to write. Even if they recognize comprehension problems, they may not be able to generate appropriate solutions to those problems. As Carole Beal (1996) noted in her review of research on comprehension monitoring in children's revision of writing, effective comprehension monitoring is necessary but not sufficient for successful revision. Children are likely to overestimate the comprehensibility of the text they have produced. Background knowledge and experience with a particular text genre influence children's abilities to monitor text adequately. By the end of the elementary school period, however, most children can evaluate text adequately and are aware of the types of problems that affect comprehension and indicate the need to revise.

Children are also able to benefit from instruction designed to increase their evaluation skills. Beal, Garrod, and Bonitatibus (1990) trained third and sixth graders in a self-questioning text-evaluation strategy. After training, these students located and revised more errors in text. They also benefited from their exposure to problematic texts and practice in applying different standards for evaluating comprehension. Children also mature in terms of the quality of the evaluative criteria that they apply to pieces of writing. In a longitudinal study of students' use of criteria to evaluate the quality of writing, McCormick, Busching, and Potter (1992) reported differences in the criteria used by low-achieving and high-achieving fifth graders to evaluate texts that they had written versus texts written by others. A year later, when these students were sixth graders, they demonstrated progression in the sophistication of their evaluative criteria.

Researchers have also reported success with broad-based instructional programs designed to improve writing skills. Raphael, Englert, and Kirschner (1989) assessed fifth and sixth graders' metacognitive knowledge of the writing process.
Research on Metacognition and Problem-Solving Skills

before, during, and following participation in different writing programs. The writing programs focused on different aspects of the writing process, metacognitive knowledge of text structures, audience, and purpose in writing. The results indicated improvement in the quality of student writing and increased metacognitive awareness in the areas on which the instructional programs focused. Engler, Raphael, Anderson, Anthony, and Stevens (1991) investigated the effects of an instructional program titled Cognitive Strategy Instruction in Writing (CSIW) on fourth and fifth graders’ metacognitive knowledge and writing performance. In CSIW, self-instructional techniques and student-teacher dialogues are used to encourage effective strategies for planning, organizing, writing, editing, and revising. Their findings indicate the facilitation of students’ expository writing abilities on the two types of expository writing included in the programs and some evidence of transfer to another text structure that was not part of the instruction.

In yet another demonstration of the effectiveness of writing programs that support the development of metacognitive skills, Graham and Harris (1994) summarized their program of research evaluating a writing intervention they call Self-Regulated Strategy Development (SRSD). Students are explicitly instructed in the writing process, in general, as well as in specific strategies for planning and revising and procedures for regulating strategies. This instruction utilizes a dialectical constructivist approach in which students actively collaborate with teachers and peers. Metacognitive information about strategies is emphasized, particularly self-regulation skills such as self-monitoring, goal setting, and self-instruction (see Zimmerman & Risemberg, 1997, for a review of self-regulation in writing). At the end of the instructional program, the students usually adopt the processes emphasized in the program, and the quality (in terms of both length and structure) of their writing typically improves. In addition, the students typically exhibit increases in their metacognition about writing and their self-efficacy for writing.

This section has focused on research exploring the role of metacognition in writing. When students sit down to write an essay, a paper, or even just a short essay response, they are essentially trying to solve a problem—and an ill-defined problem at that. In the next section of this chapter, the role of metacognition in problem solving is discussed.

RESEARCH ON METACOGNITION AND PROBLEM-SOLVING SKILLS

A very concise definition of problem solving is goal-directed behavior. Metacognition in problem solving refers to the knowledge and processes used to guide the thinking directed toward successful resolution of the problem. Problems differ from each other both in terms of specificity and structure. If the goal of the problem is clearly stated, all the information needed to solve the problem is available, and there is only one solution to the problem, then the problem is considered well defined. An ill-defined problem, on the other hand, is one in which the goal is not clear, in which information needed to solve the problem is missing or obscured, and in which it is difficult to evaluate the correctness of a solution. According to Davidson, Sternberg, and their colleagues (Davidson, Deuser, & Sternberg, 1994; Davidson & Sternberg, 1998), metacognitive skills help learners to define what the problem is, to select an appropriate solution strategy, to monitor the effectiveness of the solution strategy, and to identify and overcome obstacles to solving the problem.

Problem definition includes the formation of a mental representation that would be helpful to solving the problem (Davidson & Sternberg, 1998). An effective mental representation allows the problem solver to organize and combine information (thus decreasing memory demands), to monitor solution strategies, and to allow generalizations across problems. A mental representation that encourages generalization would be based on essential, rather than surface, features of the problem. Experts in a specific domain spend proportionately more time planning than do novices, and their problem representations tend to be more abstract than those of novices (Davidson et al., 1994). Davidson and Sternberg (1998) argued that metacognition also plays a role in representational change through selective encoding (looking for previously overlooked information), selective combination (looking for previously overlooked ways of combining information), and selective comparison (looking for previously overlooked connections to prior knowledge). Not all problem solving, however, requires restructuring. Some problems can be solved simply by remembering previous solutions—as long as the mental representation allows the problem solver to generalize across problems. When there is a seemingly spontaneous change in understanding, this is typically referred to as an instance of insight (for a discussion of insight problem solving and metacognition, see Metcalfe, 1998).

Next, the problem solver selects a solution strategy (or set of solution strategies) that would facilitate goal attainment. Metacognitive awareness of what is already known is critical in the selection of an appropriate strategy. The problem solver needs to be able to monitor the effectiveness of the solution strategies and needs to be cognizant of other potentially useful plans or of likely modifications to the selected strategies. Metacognition also comes into play in terms of being aware of obstacles to solving the problem.
Bransford, Sherwood, Vye, and Rieser (1986) described two approaches to teaching thinking and problem solving. The first approach emerged from the study of experts and focuses on the role of domain-specific knowledge. The second approach emphasizes general strategic and metacognitive knowledge. Bransford et al. suggested that metacognitive training may be able to help people improve their ability to think and learn. To that end, Davidson and Sternberg (1998) proposed a variety of approaches for training metacognition in problem solving, including modeling, peer interaction, and integration of techniques into curriculum and textbooks. Mayer (2001) emphasized the importance of teaching through modeling of how and when to use metacognitive skills in realistic academic tasks.

There is evidence that problem solvers can benefit from interventions designed to facilitate their monitoring and evaluation skills. Delclos and Harrington (1991) found that fifth and sixth graders who received problem-solving training combined with self-monitoring training solved more complex problems and took less time to solve them than did control students and those who received only problem-solving training. King (1991) taught fifth-grade students to ask themselves questions designed to prompt the metacognitive processes of planning, monitoring, and evaluating as they worked in pairs to solve problems. The students in this guided questioning group performed better on a written test of problem solving and on a novel problem-solving task than did students in an unguided questioning group and a control group. Berardi-Coletta, Buyer, Dominowski, and Rellinger (1995) found that college students given process-oriented (metacognitive) verbalization instructions performed better on training and transfer problem-solving tasks than did students given problem-oriented verbalization instructions and those given simple think-aloud instructions. The process-oriented instructions induced metacognitive processing by asking students questions designed to focus their attention on monitoring and evaluating their problem-solving efforts. In contrast, the problem-oriented instructions focused students' attention on the goals, steps, and current state of the problem-solving effort. Berardi-Coletta et al. suggested that future problem-solving research should emphasize the critical role of metacognition in successful problem solving.

RESEARCH ON METACOGNITION AND INSTRUCTION

Since it has become increasingly clear that metacognitive awareness and skills are a central part of many academic tasks, a critical question for educators is how we foster the development of metacognition in students. What follows is a description of successful interventions, many of which were designed to improve comprehension and comprehension monitoring, but the principles underlying these interventions can and have been extended to other learning contexts. These interventions can be grouped into two categories: those using an individual approach and those using a group-based approach. This section concludes with a presentation of general recommendations for instruction and classroom practice.

Individual Interventions

One of the most promising types of interventions for facilitating the development of metacognitive skills involves self-instruction as a technique to make thinking processes more visible. Miller (1985) reported that fourth graders who received either general or specific self-instructions were able to identify more text inconsistencies when reading aloud than could a control group that received practice and feedback. Moreover, the benefits of the self-instruction were maintained three weeks later. Miller, Giovenco, and Rentiers (1987) designed self-instruction training that helped students define the task ("What am I supposed to do?"), determine an approach to the task ("How am I going to do this; what is my plan?"), evaluate the approach ("How is my plan working so far?"). reinforce their efforts ("I am really doing good work"), and evaluate the completion of the task ("Think back—did I find any problems in this story?"). Fourth and fifth graders who received three training sessions in this self-instruction program increased their ability to detect errors in expository texts. Both above- and below-average readers in the self-instruction condition outperformed the students in the control group.

In another effort to help students monitor their comprehension using self-questioning techniques, Elliott-Faust and Pressley (1986) trained third graders to compare different portions of text. In the comparison training, students learned to ask themselves questions such as, "Do these parts make sense together?" For some students, the comparison training included additional self-instruction such as "What is my plan? Am I using my plan? How did I do?" Long-term improvements in the students' ability to monitor their listening comprehension, as indicated by the detection of text inconsistencies, came only with the addition of the self-instruction control instructions.

Another technique that has been demonstrated to improve comprehension monitoring is embedded questions. Pressley et al. (1987) hypothesized that having to respond to questions inserted in text as they read may make students more aware of what is and what is not being understood. As predicted, they found that college students who read texts with adjunct