1. A Process-Oriented Model of Metacognition: Links Between Motivation and Executive Functioning

John G. Borkowski
*University of Notre Dame*, borkowski.1@nd.edu

Lorna K. S. Chan
*The Hong Kong Institute of Education*, kschan@ied.edu.hk

Nithi Muthukrishna
*University of Natal, South Africa*

Follow this and additional works at: [https://digitalcommons.unl.edu/burosmetacognition](https://digitalcommons.unl.edu/burosmetacognition)

Part of the *Cognition and Perception Commons*, and the *Cognitive Psychology Commons*

[https://digitalcommons.unl.edu/burosmetacognition/2](https://digitalcommons.unl.edu/burosmetacognition/2)

This Article is brought to you for free and open access by the Buros-Nebraska Series on Measurement and Testing at DigitalCommons@University of Nebraska - Lincoln. It has been accepted for inclusion in Issues in the Measurement of Metacognition by an authorized administrator of DigitalCommons@University of Nebraska - Lincoln.
A Process-Oriented Model of Metacognition: Links Between Motivation and Executive Functioning

John G. Borkowski
University of Notre Dame

Lorna K. S. Chan
The Hong Kong Institute of Education

Nithi Muthukrishna
University of Natal, South Africa

The measurement of metacognition has gone through four overlapping phases: The first phase began with the insightful and stimulating paper of Kreutzer, Leonard, and Flavell (1975) on introspective reports about memory states and processes, followed by an important theoretical chapter on the nature of metamemory (Flavell & Wellman, 1977). These early contributions documented, and theoretically clarified, the fact that children could accurately report their knowledge about memory events as they related to a variety of tasks, circumstances, and strategies; furthermore, memory knowledge was shown to be age-related. A second phase quickly followed: The intention here was to show interconnections between memory knowl-
edge and memory performance. Although hindsight now reveals that a modest relationship \( r = .42 \) links metamemory and memory across a wide range of learning contexts (Schneider & Bjorkland in press), an uncomfortable feeling about the “fuzziness” of the concept prevailed during this second stage of research (Wellman, 1983). From our vantage point, three interrelated conceptual and methodological problems surfaced that hindered the search for reliable and valid measures of metacognition—problems that continue to influence contemporary research and theory development:

1. Lack of clear definitions for each metacognitive construct (especially about when, where, and to whom a construct applies).
2. Lack of an array of well-analyzed tasks that permit the separation of process and performance measurements.
3. Lack of a variety of measures that converge on a given construct from multiple directions.

The third and fourth waves of research—which dominate the majority of present day studies on metacognition—focus on the issues of monitoring and control (which we refer to as executive functioning) and their associations with a variety of motivation variables. This research has been inspired, in large part, by the enthusiasm for metacognition theory, and its instructional implications for the educational reform movement. It is not surprising that current research on metacognition is more commonly found in educational psychology than in developmental psychology.

**METACOGNITION AND GOOD INFORMATION PROCESSING**

The function of metacognitive theory is to help explain successes and failures in strategy generalization. It is a theory confined principally to complex and/or novel tasks because strategies assist learners in carrying out essential cognitive operations that produce efficient, insightful learning. Strategies are at the heart of most important challenging academic activities, such as reading a difficult text passage or preparing for an examination. It is important to note that strategies are not necessarily conscious, only “potentially conscious.” Pressley, Forrest-Pressley, Elliot-Faust, and Miller (1985) have provided us with a useful definition of a strategy:

> [strategies]...are composed of cognitive operations over and above the processes that are a natural consequence of carrying out [a] task, ranging from one such operation to a sequence of interdependent operations. Strategies achieve cognitive purposes (e.g., memorizing) and are potentially conscious and controllable activities. (p. 4)
Over the last few years, the goals and prerequisites for effective strategy-based learning and instruction have been clarified by an exposition of the states and processes that comprise metacognition (Borkowski & Muthukrishna, 1992; Pressley, Borkowski, & Schneider, 1990). These goals include a clear focus on the teaching and learning of a wide variety of strategies, the higher-level processes necessary for their implementation, and the self-system (and motivational beliefs) that are their consequences as well as their sources of actualization (Borkowski, Carr, Rellinger, & Pressley, 1990). This chapter presents a process-oriented model of metacognition that is useful in understanding the ways in which strategies develop and the reasons for their generalized use over time and settings. The focus is on executive functioning and attributional beliefs, how they are conceptualized and measured, and their developmental origins.

Components of the Metacognitive System

Strategy-based learning is deliberate and effortful, at least with novice learners. It usually produces a higher level of performance than nonstrategic learning. This kind of learning is an integral aspect of what we have called Good Information Processing (Pressley et al., 1990). Although somewhere a teacher may discover a child who actually mirrors our conceptualization of the Good Information Processor, it is a rarity. Although aspects of the theory we espouse can be observed in reality, the entire model serves more as a long range goal for facilitating children’s learning through the full development of metacognitive skills than as an accurate depiction of “normal” development. Other chapters in this volume (especially those of Pintrich and Pressley) also suggest that declarative memory knowledge, memory monitoring, and cognitive self-regulation are at the heart of metacognitive theory. It is the development and integration of knowledge with higher-order skills and beliefs that are the foci of this chapter.

The unique aspect of the Good Information Processing model lies in the successful integration of the main components of the metacognitive system—including cognitive, motivational, personal, and situational characteristics. As Borkowski and Muthukrishna (1992) have argued, most of the major components of metacognition are, or can be, developed and reshaped by carefully planned classroom and home-based learning experiences—experiences that begin early and continue throughout the life-span. We have outlined 10 major characteristics that define a child who is a “Good Information Processor” (Borkowski & Muthukrishna, 1992).
1. **Knows** a large number of useful learning **strategies**.
2. **Understands** when, where and why these strategies are important.
3. **Selects** and **monitors** strategies wisely, and is extremely **reflective** and **planful**.
4. Adheres to an **incremental** view regarding the growth of mind.
5. **Believes** in carefully deployed **effort**.
6. Is **intrinsically motivated**, **task-oriented**, and has **mastery goals**.
7. Doesn’t **fear** failure—in fact, realizes that failure is essential for success—hence, is not **anxious** about tests—rather sees them as learning opportunities.
8. Has concrete, multiple images of “**possible-selves**,” both hoped-for and feared selves in the near and distant future.
9. **Knows** a great deal about many topics and has rapid **access** to that knowledge.
10. Has a history of being **supported** in all of the above by **parents**, **schools**, and **society at large**.

The relevant background literature and different rationales for these characteristics can be found in Ames and Archer (1987); Borkowski et al. (1990); Pressley et al. (1990); Deci and Ryan (1985); Markus and Nurius (1986); Nicholls (1984; 1989); and Pressley, Gaskins et al. (1991). Several characteristics, however, are essential aspects of our view of metacognition and deserve highlighting: (a) Strategies learned out of context, or in the rote fashion, will usually prove transient. Thus, Characteristic 2 implies that developing an in-depth awareness of how each strategy works is critical for generalized strategy usage. (b) Executive functioning is the most important process in the entire metacognitive system. Hence, Characteristic 3 emphasizes the essential role of task analysis, planfulness, and reflectivity in strategy selection as a student confronts a problem or task; the need to monitor its ongoing effectiveness; and, perhaps, to replace it with a more viable strategy. (c) Beliefs about hard work in analyzing tasks and selecting strategies as well as an orientation toward solving the task-at-hand rather than pleasing others are important motivational processes that energize self-regulatory processes. In this sense Characteristics 5 and 6 (which are motivational in nature) are related to Characteristic 3 (executive functioning or self-regulation). (d) Students need to visualize themselves in near and far time-frames in order to develop meaningful goals that will actualize the
metacognitive system at critical moments of difficulty and frustration in the course of learning and problem solving. Thus, the concept of possible selves (Characteristic 8), though understudied and not well understood, may eventually be useful in understanding why strategies are abandoned in adolescence or adulthood, in both the school and workplace. (e) Consistency in strategy instructions—across time and settings (Characteristic 10)—seems essential for lifelong strategy use to occur, for the continued development of the metacognitive system, and for the reliable and valid measurement of the components of metacognition. Some of the measurement problems encountered in this field may be due as much to inconsistencies in instruction as to the fickleness of cognitive development (cf. Siegler, 1995).

The Development of Metacognitive Theory

After outlining the major characteristics of Good Information Processing, it is useful to illustrate how these characteristics become interrelated by suggesting how the essential components of metacognition might plausibly develop. Borkowski and Muthukrishna (1992) have traced metacognitive development in terms of what happens to a child who receives high quality, interactive strategy instruction in both the home and school:

1. The child is initially taught to use a learning strategy and, with repetition, comes to learn about the attributes of that strategy (this is called specific strategy knowledge). These attributes include the effectiveness of the strategy, the range of its appropriate applications, and how to use it with a variety of tasks. Figure 1 shows how a simple strategy (such as summarization), in isolation from the rest of the system, can be expected to produce an improvement in performance.

2. Next, the child learns other strategies and repeats them in multiple contexts. In this way, specific strategy knowledge is enlarged and enriched. Figure 2 presents a schematic diagram showing the emergence of a number of specific strategies. The child comes to understand when, where, and how to deploy each strategy.

3. The child gradually develops the capacity to select strategies appropriate for some tasks (but not others), and to fill in knowledge gaps by monitoring performance, especially when essential strategy components have not been adequately taught. At this stage, higher-order executive pro-
Figure 1. A primitive view of the strategy use-performance relationship.

Specific Strategic Knowledge

Task → Strategy Use → Performance

Figure 2. Multiple strategies and performance.

Specific Strategy Knowledge
1. Repetition
2. Organization
3. Verbal Elaboration
4. Summarization
5. Etc.

Task → Strategy Use → Performance
cesses emerge. This is the beginning of self-regulation, the basis for adaptive, planful learning and thinking. Figure 3 shows the relationship of executive processes to specific strategies. Initially, the function of the executive is to analyze the task at hand and to select an appropriate strategy; during the course of learning, its role shifts to strategy monitoring and revision.

Figure 3. Executive functioning and strategy use.

4. As strategic and executive processes become refined, the child comes to recognize the utility and importance of being strategic (general strategy knowledge accumulates), and beliefs about self-efficacy develop. In addition, as the child acquires domain-specific knowledge and skills, beliefs about efficacy become differentiated across domains. More specifically, children learn to attribute successful (and unsuccessful) learning outcomes to effort expended in strategy deployment rather than to luck or to task difficulty encountered in specific domains of study. Furthermore, some children come to understand that through self-directed actions mental competencies can be enhanced.
In these ways, the metacognitive model integrates cognitive acts (in the form of strategy use) with their motivational causes and consequences. Figure 4 suggests that following most cognitive acts, the child is often provided with, or infers, feedback about the correctness of performance and its specific cause(s). This feedback is essential for shaping personal-motivational states (e.g., attributional beliefs, which in turn can energize the executive processes necessary for strategy selection and deployment in future situations.

5. A sense of self-efficacy and an enjoyment of learning flow from individual strategic events and eventually return to energize strategy selection and monitoring decisions (i.e., executive processes). It is this latter connection—the association between the learner’s reasons for learning and the deployment of self-regulation—that has been absent from most instructional programs. This theme is at the heart of our most recent extensions of metacognitive theory (Borkowski et al., 1990; Borkowski & Muthukrishna, 1992).

Figure 4. Motivational correlates and causes of strategy use.
6. General knowledge about the world as well as domain-specific knowledge (e.g., math) accumulate. Such knowledge is often sufficient to solve problems, even without the aid of strategies. In these situations, metacognitive processes, such as strategy selection are unnecessary, although some motivational components may remain functional and important (see Figure 5).

7. Crystallized visions into the future help the child form a number of “hoped-for and “feared” possible-selves (Markus & Nurius, 1986) providing the impetus for achieving important short-term as well as long-term goals, such as becoming a “competent student” in order to eventually become a “successful lawyer” (cf. Day, Borkowski, Dietmayer, Howsepiam, & Saenz, 1992). In this way the self-system takes on a futuristic perspective, providing goals and incentives that stimulate the operation of the entire metacognitive system. The complete metacognitive model, including the self-system and the domain-specific knowledge “bypass,” is presented in Figure 5.

In summary, the centerpiece of metacognitive theory is strategy selection and use. Not only are specific strategies essential for effective learning and problem solving, they also provide the context for training higher-level planning and executive skills explicitly as well as represent the basis for restructuring attributional beliefs and enhancing self-efficacy. As such connections are formed and ingrained, instructional emphasis can shift to their interface with domain-specific knowledge and the explicit incorporation of possible-selves training into individualized curricula. It is hoped that the net result of integrating and instructing these central and peripheral components of metacognition will be the production of more effective and efficient students, who share many of the characteristics of the “Good Information Processor” (Pressley et al., 1990)

A Test of the Model

Measurement approaches. There are three general approaches that have been used to manipulate and/or measure components in the metacognitive model during the first two decades of research on this topic:

1. Set up conditions in which no other processes appear as reasonable, alternative theoretical explanations.
2. Instruct processes directly (and hope that “nothing else” has been trained).
3. Develop a broad-based (or domain-specific) questionnaire that reflects students' use of (or beliefs about) the attributes of a metacognitive state or process and relate individual differences to performance. Several points of clarification about these measurement approaches are in order. First, they need not be mutually exclusive; for instance,
it is possible (and desirable) to train and assess processes and beliefs within the same study (i.e., Parts 2 and 3 combined). Second, the first two approaches demand a theoretical respect for a clear distinction between process and performance as they relate to metacognitive measurement. In a seminal paper, Belmont and Butterfield (1977) argued that by measuring performance, separate from the processes from which it presumably flows, research on cognitive development stands on firmer theoretical ground, especially when inferring the former from the latter. Third, although we have listed only three historically rooted research approaches to measurement, the new technique advocated by Pressley (this volume)—think aloud, protocol analysis—represents a powerful context in which to observe and measure metacognitive activity as it is occurring.

At times, metacognitive research has utilized all three measurement approaches. From our vantage point, this style of research is a particularly powerful way to validate metacognitive models, especially if the combination of approaches results in internal replication. In our own research program, a study by Reid and Borkowski (1987) contains aspects of all three methodologies, especially the latter two (process manipulations and questionnaires designed to assess changes in performance, strategy use, attributional beliefs, and cognitive styles following a multi-faceted strategy-based intervention).

Before describing the Reid and Borkowski (1987) study in detail, it should be noted that there are relatively few studies where the researchers have tried to assess how the major components of metacognition interrelate. The reason is that it is difficult to manipulate, or observe, metacognitive components in isolation from one another. This is an important point for measurement in this area. It is also the case that theoretically distinct components may not be entirely separate from one another as they operate in the real world: It is often easier to develop theories with boundaries and boxes than to locate, isolate, and measure these same processes in laboratory or observational settings. In order to be assessed reliably, components of metacognition may need to be measured in the midst of their complex interactions, rather than in isolation.

An integrated approach. In an early study of interrelationships among the components of metacognition, Reid and Borkowski (1987) attempted to establish the plausibility of the metacognitive model with children who were learning disabled. The unique and combined effects of training specific strategy knowledge, teaching self-control skills, and reshaping attributional beliefs about the importance of effort were studied. More specifically, three treatment groups were
compared: a self-control condition, a self-control plus attributions condition, and a control condition. In the self-control condition, the teacher modeled self-verbalization procedures for the child (e.g., “look to see how the problem might be solved; stop and think before responding”). These self-control procedures were taught in the context of specific strategy training, which focused on the use of interrogative-associative mediators appropriate for a paired associate task and a clustering-rehearsal strategy for use on a sort-recall readiness task.

In the self-control plus attributions condition, children received strategy and self-control instruction as well as attributional training designed to enhance both antecedent and program-generated self-attributions. Antecedent attribution training took the form of a discussion focusing on general, pervasive beliefs about the causes of success and failure; children were also given opportunities to perform previously failed items in the self-control package. Program-generated attributions consisted of feedback about the relationship between strategic behavior (or its absence) and performance during paired-associate learning. Individual items were shown to be correct or incorrect depending upon whether effort was put forth in deploying the appropriate strategy. The control group received the same amount of strategy training as the experimental groups but did not receive self-control or attributional training.

Widespread strategy generalization occurred on a 3-week posttest in the self-control plus attributions condition. More importantly, the persistent use of strategies was maintained at a 10-month follow-up. In addition, attributional beliefs and metamemory were permanently altered in this condition. These results seem surprising in light of the longstanding difficulties in obtaining strategy generalization. For example, Gelzheiser (1984) was unable to obtain extensive generalization in learning-disabled children following prolonged training; attributional retraining, however, was not a component in her instructional package. We believe that the emphasis on strategy-based effort set in motion a bidirectional chain of events between strategic acts and the growth of positive beliefs about the importance of effort in deploying strategies. The net result was that children who, for the most part, were not spontaneous strategy users at the study’s outset, deployed strategies with greater flexibility and persistence up to 10 months following the end of training.

The intervention program in the Reid and Borkowski (1987) study contained three key components: detailed information about two specific strategies, self-control procedures useful in implementing
these strategies, and an explicit recognition of the role of effort and personal causality in producing successful performance. The interaction of these metacognitive components seemed to play an essential role in the generalization of strategic behaviors. These results, together with those of Borkowski, Weyhing, and Carr (1988) and Carr and Borkowski (1989) on the explicit training of attributional beliefs in the context of reading comprehension instructions, lead us to believe that long-term changes in strategic behaviors are probably dependent on the development of complex relationships among components in specific strategy knowledge, self-regulation, and motivational beliefs. In a sense, this set of studies has expanded the boundaries of cognitively based interventions by focusing on how self-regulation, the heart of metacognition, depends on children's rationales and attitudes about the learning process per se and how they conjointly contribute to academic achievement.

In subsequent sections, we trace more recent advances in the theory and measurement of executive functions and attributional beliefs. Finally, we suggest specific contexts that influence the integrated development of metacognition with a view toward understanding more about situational factors related to when and where metacognitive measures should best be gathered.

THEORIES OF EXECUTIVE FUNCTION

Although the major components of executive functioning are by no means agreed upon, most researchers would concur that the three components represented in Figure 6 are essential. The first, and perhaps most essential, component, is task analysis. Despite its centrality in defining executive processing, it is the most poorly understood, and least often measured process in the system. The importance of task analysis lies in its potential for explaining generality across settings and domains. This aspect of the executive is critical because its proper execution is essential for the occurrence of the second activity—strategy selections. A related component—strategy revision—is closely linked to strategy selection and is observed on tasks that allow for the measurement of continuous changes in the processes that determine successful performance in the face of changing task demands. It is probably methodologically easier—and perhaps theoretically wiser—to measure strategy revisions than initial strategies selection in that "moments" of strategy change are likely to be more reliably assessed than strategy initiation (Siegler, 1995). The most widely studied attribute of executive processing is strategy monitoring,
which has a long and substantial history in developmental, educational, and cognitive psychology (Borkowski, Milstead, & Hale, 1988; Schneider & Pressley, 1997). Pintrich (this volume) does an excellent job of classifying the types of monitoring tasks that have been used in metacognitive research, and Schraw, Dunkle, Bendixen, and Roedel (1995) have recently suggested that monitoring skills are often domain general. We turn now to a review of several theoretical positions that describe the interrelationships among, and the functioning of, the major components of executive functioning as well as their connections with other aspects of cognitive systems.

Figure 6. Major attributes of executive functioning.

Components of Executive Functioning

- TASK ANALYSIS
- STRATEGY CONTROL (SELECTION & REVISION)
- STRATEGY MONITORING
Butterfield's Theory of Executive Functioning

Butterfield, Albertson, and Johnston (1995) have developed a new theory of cognition in which executive functioning plays a critical role. In their model, cognition, metacognition, and executive functioning are three major components. The cognitive level consists of all the knowledge and strategies that exist in long-term memory; this reservoir of information about the cognitive system is critical for effective problem solving. The metacognitive level represents awareness of the cognitive level and contains "models" of the various cognitive processes as well as an understanding of how knowledge and strategies interconnect. This level is the unique aspect of the Butterfield et al. (1995) theory in that it rests on the interesting assumption that metacognitive skills are generalizable—but only if students develop mental models in their cognition system. Furthermore, the metacognitive level is potentially trainable.

Executive functioning coordinates the two levels—the cognitive and the metacognitive—by monitoring and controlling the use of the knowledge and strategies in concordance with the "mental model building." Thus, in the Butterfield et al. (1995) theory, in contrast with the theory of Day, Borkowski et al. (1992) described earlier, the metacognitive level is distinct from the mechanisms that help to control and monitor the cognitive level. For Butterfield these mechanisms seem to represent executive functioning in operation.

The concepts of monitoring and control, which are responsible for the emergence of complete and mature mental models, allow for the possibility of a more general theory of cognition than has previous task-specific theories. Butterfield et al. (1995) believe that individuals are able to create mental models about their own cognitions based on their day-to-day problem solving activities. They suggest that these models are similar to those developed by scientists through prolonged, detailed task analysis. Self-generated models exist in direct relation to the knowledge and strategies present at the cognitive level. The development and integration of task-specific models, made possible by executive functioning, eventually lead to a personalized (and unified) theory of cognition. Individuals who possess such unified theories, according to Butterfield and Albertson (1995), should show more rapid acquisition and more extensive generalization of skills and strategies across domains.

Bransford's Ideal Problem Solver

Bransford and Stein (1993) have incorporated aspects of executive functioning into their model of the IDEAL problem-solver. The
acronym, IDEAL, is used to symbolize the skilled components in problem-solving: (a) *Identify* an important problem to-be-solved; (b) *Define* the subgoals involved in solving the problem; (c) *Explore* possible approaches to the problem, that is, select a set of potential strategies; (d) *Anticipate* potential outcomes before acting on the best initial approach; and (e) *Look* back and learn from the entire problem-solving experience. Because these five steps are used flexibly by expert problem-solvers, they do not always occur in the same fixed order nor is each step necessary for all problem-solving tasks.

These five steps, proposed by Bransford and his colleagues, closely resemble the components of executive functioning discussed earlier. The first steps—problem identification and definition—represent a form of task analysis. The discovery and definition of an existing problem shape the next steps—exploring approaches and anticipating outcomes. In these steps, various strategies are considered and the best alternative is chosen. The last step of the IDEAL problem solving strategy involves looking back and learning from prior efforts. In the ongoing process of problem solution, this step is at the heart of what we have called *strategy monitoring and revision*.

Bransford and his colleagues have incorporated aspects of the IDEAL problem-solver into their video-based technology research. The Cognition and Technology Group at Vanderbilt has developed a technology that anchors and situates instruction in shared environments, thus permitting sustained exploration by students and teachers (Bransford, Sherwood, Hassebring, Kinzer, & Williams, 1990). Students experience the value of exploring the same setting from multiple perspectives (e.g., as a scientist, historian, and mathematician). As they discover their own issues to explore in these enriched environments, they communicate their ideas to other students and develop analytic skills as a result of their problem-solving activities. Difficult to discern in the research of the Vanderbilt group are the precise sets of metacognitive skills that emerge as a result of these shared experiences, and their reliable measurement, as students acquire prolonged experience with video-based instruction. What specific problem-solving strategies are developed? Are higher-level planning, task analytic, or monitoring skills (i.e., executive functioning) enhanced? Are specific beliefs about self-efficacy and the personal challenge to develop one’s own mind explicitly fostered?

We suspect that a comprehensive, and carefully used, video-technology approach to instruction influences the emergence of planning and executive skills as well as enhances motivational beliefs about self-efficacy. More precise assessment of these characteristics
would help to advance the metacognitive aspects of the theories that underlie video-technology. It is to the measurement of personal beliefs, and other motivational states, that we now turn.

**ATTRIBUTIONAL BELIEFS AND METACOGNITION**

An important component of the personal-motivational states in the metacognitive model is what students perceive as the causes of their successes and failures in school. The most common reasons students give for their successes and failures are ability, effort, their attitude (such as interest), physical factors (mood, fatigue, etc.), task difficulty, assistance from others, and luck. Weiner (1983, 1984) has classified these attributions as either internal or external locus, constant or variable over time and across different situations, and controllable or uncontrollable by oneself. For example, ability attributions have an internal locus, are stable but uncontrollable whereas effort attributions have an internal locus, are unstable (therefore can be changed) but are controllable. Each of these dimensions is proposed to be uniquely associated with particular psychological consequences. The locus dimension affects self-esteem (e.g., attributing success to internal factors increases self-esteem). The stability dimension relates to changes in expectancy of success or failure and affective reactions (e.g., attributing failure to a stable cause such as lack of ability leads to high expectancy of future failure and hence feelings of hopelessness). The controllability dimension relates to sentiments and evaluations of others (e.g., if a student fails because of a controllable cause, such as lack of effort, anger is often elicited and the student is negatively evaluated). Affective reactions and anticipations in conjunction with expectancy of success are assumed to affect a student’s willingness to try, persistence, choice or avoidance of tasks, and, eventually, task performance.

Research has indicated that students who attribute their successes and failures in school tasks to internal and controllable sources (e.g., one’s own effort) are more likely to persist in the face of difficulty (Nicholls, 1984; Weiner, 1984). If students are convinced that success or failure depends on effort, they will realize that they can expect success if they put in the required effort. These students who have internal perceptions of control have high expectancy of success and are motivated to work hard because they realize that success or failure will depend on their own effort. On the other hand, students who attribute successes and failures to external or uncontrollable sources (e.g., powerful others, luck, task difficulty, or inherent abilities) are
more likely to give up when they come across difficulties in their learning. Students who attribute school success to luck will not be confident of maintaining that success at all times and will not be motivated to expend maximum effort to attain prescribed learning goals. Likewise, students who think that their progress in school depends entirely on teachers’ skills will not be motivated to become independent in learning. Furthermore, they will not be motivated to try hard because they do not see that their effort will contribute to success.

It has been widely accepted that beliefs in personal control over task outcomes can be promoted by convincing students that school successes and failures are attributable to effort. Such an approach has not been entirely successful. Some students, particularly students with learning difficulties, may find that they keep on failing in spite of increased effort, particularly if they do not know how to try harder. Such negative experience would even further reinforce their beliefs in the lack of ability, and thus increase feelings of helplessness. Probably a more fruitful direction is to try getting these students to attribute failures to both insufficient effort and ineffective task analysis (Borkowski, Weyhing, & Turner, 1986; Clifford, 1986; Licht & Kistner, 1986). There are many advantages of encouraging strategy attributions in students, including the elimination of the guilt associated with not trying hard or the embarrassment and public shame associated with being stupid. More importantly, strategy attributions allow failure outcomes to be seen as problem-solving situations in which the search for a more effective strategy becomes the goal (Clifford, 1986). Indeed, effort and strategy attributions play a critical role in the developmental aspects of metacognitive theory.

Role of Attributional Beliefs in Metacognitive Theory

As discussed earlier, the centerpiece of metacognitive theory is strategy selection and use—that is, the operation of executive function in the form of self-regulation. It was explained in the previous section that executive functioning is responsible for the planning, selecting strategies, monitoring, evaluating, and revising ongoing performance in learning and problem solving. Such planning, evaluating, and regulating processes require effort, initiation, and willingness to try, as well as persistence. Furthermore, there needs to be some minimal expectancy of success before a student is prepared to try, marshal the appropriate effort, and persist when encountering difficulties. If there is little or no expectancy of success, students will likely expend little
1. PROCESS-ORIENTED MODEL OF METACOGNITION

... effort in learning, or they may even actively avoid tasks that they perceive will eventuate in failure. Hence, the assessment of attributional states likely represents an essential step in measuring any aspect of executive functioning.

Before students are prepared to deploy effort in planning, evaluating and regulating strategy use, they must develop and maintain four beliefs:

1. The value of good performance on the task at hand: That is, they must want to do well and strive to obtain a good result;
2. Personal control over task outcomes: That is, they must be convinced that success or failure on the task depends on themselves;
3. Usefulness of strategy use: That is, they must have the knowledge that use of specific strategies will lead to better performance on the task;
4. Their ability to use strategies effectively and successfully: That is, they must perceive themselves as capable and competent.

In other words, students who are committed to do well on a given task, who have well-developed specific strategy knowledge, and who believe that their effortful use of strategies will lead to successful task performance are likely to be active in strategy selection, monitoring, and regulation. Empirical support for these theoretical propositions is starting to emerge. For instance, perceptions of personal control (effort and strategy attributions) have been shown to relate positively to knowledge and use of strategies, and to academic performance (Borkowski, Weyhing, & Carr, 1988; Chan, 1994; Chan, 1996a). Further, the pattern and impact of attributional beliefs appear to change across the school years (Clayton-Jones et al., 1992).

In the Clayton-Jones et al. study, students from grades 4, 6, 7, 9, and 11 were administered a general attribution scale incorporating ability, luck, effort, and strategy attributions for success and failure. For the primary grade children, effort attribution for success was positively related to achievement in Math and English (a combined score) but at grade 9, strategy attribution for success emerged as a positive predictor of achievement. Ability attribution for failure, however, was a pervasive negative influence across all grades.

The positive effects of beliefs in personal control over task outcomes on the use of strategies were also observed in both gifted and average ability students in grade 7 (Chan, 1996a). Indeed, the relationship between attributional beliefs and use of strategies was fur-
ther clarified in the Chan (1994) study involving 104 grade 5, 133 grade 7 and 101 grade 9 students. Path analysis results indicated that students in the higher grades (7 and 9) who believed that they had personal control over learning outcomes, who were not inclined to feel helpless in their learning, who had high self-perceptions of cognitive competence, and who had good knowledge of strategies, were more likely to use strategies in their learning. For grade 5 students, however, only the perceived competence measure was found to influence use of strategies. When reading achievement was included, hierarchical regression analyses revealed that although the attributional beliefs and perceived competence had a more important role (relative to strategic learning) in explaining reading achievement in the younger grades, in grade 9 the role of the strategy knowledge and usage variables was as important, if not more important, as the motivation variables. Path analyses results clarified these relationships: Knowledge and use of strategies were found to mediate between the effects of attributional beliefs and perceived competence on reading achievement for grade 9, but not for the younger grades. Results of the grade comparisons indicated that strategy attributions were not prominent in students' attributional beliefs before grade 9. This result could explain the lack of influence of strategy knowledge and usage on reading achievement in the younger students.

Assessment of Attributional Beliefs

The findings of the research studies described above highlight the complex relationships between the various components of metacognition and their developmental differences. It follows that to advance our knowledge and understanding of the development of metacognition, the components of metacognition should be studied as they interact with each other in specific learning contexts and from a developmental perspective. The study of students' attributional beliefs and their impact on the executive processes and academic performance provides a useful example to illustrate this principle. This entails as a starting point the search for effective means for obtaining information on attributional beliefs. This is not an easy task because students themselves are not fully conscious of the existence of learned helplessness or control beliefs, or they may encounter difficulty in reporting their causal attributions. We now turn to some of the issues in the assessment of attributional beliefs that need to be addressed.

Assessment method. Earlier research on causal attributions in school learning tended to measure attributional beliefs by requiring
respondents to choose a single major cause. The resultant attribution was then classified as internal or external, stable or unstable, controllable or uncontrollable according to Weiner’s (1984) classification scheme; inferences were then drawn as to the likely psychological and behavioral consequences. However, the unquestioned acceptance of the categorization often causes confusion as it was often the perceived stability from the perspective of the respondent, rather than the stability implied by the objective task characteristics, that was the determinant of the affective outcomes (Weiner, 1983; 1984). To measure attributional beliefs, respondents could be asked to rate the cause in question on the stability or controllability dimensions directly rather than using an a priori classification of the causes. However, the differential consequences of the various combinations of locus, stability, and controllability dimensions complicates such an approach. This is particularly so when the dimension of intentionality is subsequently added (Weiner, 1984).

Elig and Frieze (1979) compared different methods of assessing causes of success and failure, including open-ended questions (e.g., why do you think you succeeded on this task?), independent unipolar ratings (e.g., rate each given cause on a 5-point scale), ipsative measures such as percentage assessment (e.g., provide a percentage contribution for each given cause), choice of one cause (select one from a given set), bipolar ratings (rate each of two causes that are different on a particular dimension), and paired comparison (from among several causes). Results indicated that the independent unipolar rating method was the superior technique as it had good face validity, did not force intercorrelations among attributions, and had moderately good intermethod correlations with percentage measures.

Strategy use as a distinct attribution. As yet little research has been done in the development of attributional beliefs with respect to the use of strategies. Most of the extant work has focused on attributions to ability versus effort (e.g., Cooley & Ayres, 1988; Kistner, Osborne, & LeVerrier, 1988; Wigfield, 1988). Given the critical role played by effort and strategy attributions in energizing the executive processes in the development of metacognition, we need to extend our current knowledge on the development of strategy-related attributions.

Research findings have indicated that children’s concepts of ability become differentiated with age (Nicholls, 1978; Nicholls & Miller, 1984). From a review of research, Stipek and Maclver (1989) concluded that children in preschool and early elementary school have a global concept of ability that includes social behavior, work habits, and conduct, and that they conceptualize ability as an “instrumental-
incremental” skill that is increased by practice and effort. Over the primary school years (third to sixth grade), children’s definitions of intellectual ability become narrower and the concept of ability as a stable trait emerges. However, it is not until early adolescence that they fully differentiate ability from effort and conceptualize ability as an “entity” unaffected by effort. Nicholls (1978) suggested that this mature concept of ability as a stable trait, unaffected by effort, requires an understanding of the reciprocal relationship between effort and ability—that ability limits the effectiveness of effort and that effort is more facilitative of performance in high-ability than in low-ability individuals. Clearly, some form of formal operational thought is necessary for this understanding to emerge. Apart from cognitive development, systematic changes in the activities, organization, evaluation practices, and ability-grouping patterns that children are exposed to in school may also contribute to developmental shifts in children’s ability judgments (Stipek & Maclver, 1989).

Likewise, the differentiation of the concept of strategy use from effort may also be age-related, particularly because strategy instruction has not been given much emphasis, at least until recently. It is critical to find out when strategy attributions becomes prominent in students’ motivational orientations. Some evidence is emerging from the Chan (1994) study described earlier, suggesting that the differentiations between ability, effort, and strategy attributions may not occur fully until the high school years. Furthermore, data from a recent cross-sectional project (Chan & Moore, 1994) gave support to the distinctiveness of strategy attributions as separate from ability, effort, and luck attributions.

Subject-specificity. Most of the research on causal attributions has been limited to general notions of learning rather than learning in specific subject domains. Marsh, Cairns, Relich, Barnes, and Debus (1984), however, maintained that there is good evidence for the separation of attributions according to academic subject matters, at least in the case of ability attributions. The results of their study suggest that attributional responses students make do not generalize across academic subject domains and two subject-specific dimensions (ability in mathematics and reading) can be identified. It was suggested that ability attributions are specific to academic content, but effort attributions and external attributions may not be subject-specific. Similarly, strategy attributions may also depend on specific subject domains. These findings suggest that students held different attributional beliefs for different school subjects. Such research provides rather compelling evidence for moving to subject-specific as-
sessments as well as global assessments of motivation and strategic knowledge.

Development of a Causal Attribution Scale

A 10-item rating scale was developed and used in several research projects (e.g., Chan, 1994; Chan, 1996a, 1996b; Clayton-Jones et al., 1992) to assess students’ tendency to attribute their school success and failure experiences to the four likely reasons of effort, ability, strategy use, and luck. Five items describe success incidents (such as doing well on a test), and the other 5 describe failure incidents. For each item, four different reasons are listed and students are required to rate each on a 4-point scale to indicate how true they consider that particular reason to be for them. Two versions were constructed, one for high school students and one for primary students. The content in the versions was the same, only the wording was modified to suit the students’ grade level. The following is a sample item from the high school version:

<table>
<thead>
<tr>
<th>Rarely True</th>
<th>Sometimes True</th>
<th>Often True</th>
<th>Almost True</th>
</tr>
</thead>
</table>

1. When you received a bad school report, it was probably because

a. you aren’t very good at schoolwork 1 2 3 4
b. you didn’t try very hard 1 2 3 4
c. you didn’t have any useful methods for studying 1 2 3 4
d. you were having a lot of bad luck at the time 1 2 3 4

Each of the four types of reasons (effort, ability, strategy use, and luck) is grouped across the five success items and the five failure items, respectively, thus yielding eight separate subscales. For example, a high score on the Failure-Ability subscale indicates greater tendency of attributing school failure experiences to a lack of ability. Based on this general version, three other scales were subsequently developed, one for English/Reading, one for Mathematics and one for Social Studies. In the subject-specific scales, the subject area (e.g., math) was specified or inserted in place of expressions like “schoolwork.” Again, two versions—for primary and high school students—were developed for each subject area, thus giving a total of eight causal attribution scales.
As part of a 3-year longitudinal study, Chan and Moore (1994) administered these scales to 354 students in grade 5, 650 in grade 7, and 450 in grade 9. The data from the Causal Attribution Scales were subjected to several Confirmatory Factor analyses using the LISREL (Joreskog & Sorbom, 1989) to examine the invariance of factor patterns across grades and across subject areas. The use of Confirmatory Factor Analysis allows the fit of a hypothesized a priori factor pattern, indicating which items should load onto which factors, to be tested against the empirical data. The analysis provides goodness of fit statistics, which indicate how closely a matrix obtained from parameter estimates for the posited model correspond to the input correlation or covariance matrix calculated from the data. Each set of four subscales (effort, strategy, ability and luck attributions) for success and failure for the three grade levels, as well as the combined total group, was analyzed separately. Overall, results confirmed a four-factor pattern in each case, with the items loading clearly on the intended factors. At the same time, there was some indication that the distinctiveness of the strategy attribution from the effort and ability attributions increases with age. This was seen in the decrease in the factor correlations and in the cross-loading of the factor score regressions from grade 5 to 9.

A preliminary analysis of data from the general and subject-specific scales revealed only moderate correlations between the general and the English, Mathematics and Social Studies scales. The correlations ranged from .55 to .61 for ability attributions, .56 to .65 for strategy attributions, .64 to .79 for effort attributions and .60 to .62 for luck attributions. Furthermore, ANOVA results revealed subject-domain differences as a function of grade level for ability and effort attributions, independent domain and grade level differences for strategy attributions, but no differences for luck attributions (Moore & Chan, 1995). For example, students were more likely to make ability attributions for failures in specific subject-domains than in the global domain, and the younger students were more likely to make ability attributions for successes in English/Reading than in the other domains. Whereas younger students were more likely to make effort attributions for successes in English/Reading and Social Studies than in Maths and the global domain, the subject-domain differences observed among the older students were in the reverse direction: They were more likely to make effort attributions for successes in Maths and in the global domain than in English and Social Studies. For strategy attributions, students were more likely to attribute failures in specific subject domains rather than the global domain to their
lack of effective strategy use, whereas the reverse was observed for successes. No grade level nor subject-domain differences were observed for luck attributions. These findings once again illustrate the need to consider contextual and developmental differences in any study of metacognition and its components.

Pattern of Attributional Beliefs: Adaptive versus Maladaptive

In interpreting the scores from the Causal Attribution Scale, and to make inferences as to the consequences of particular beliefs, we need to examine the pattern of a student's tendency to attribute success or failure to ability, effort, strategy, or luck. The likelihood of making any one of these attributions by itself is not sufficient to allow meaningful assessment of the components of metacognition as they interact. To minimize the number of measures to be included in an analysis as well as to facilitate interpretation of the results, the eight attribution subscale scores can be combined to form two or more variables (e.g., a "belief in personal control" variable, which can be the mean of ability, effort, and strategy attributions for success and effort and strategy attributions for failure; and a "learned helplessness" variable, which can be the mean of luck attribution for success and ability attribution for failure).

In the previously noted Chan (1994) study using students from grades 5, 7, and 9, significant differences were observed between students with and without learning difficulties (LD) on such patterns of adaptive versus maladaptive attributional beliefs. LD students were more likely than the non-LD group to attribute successes to luck and failures to lack of ability or bad luck, but less likely to attribute successes to effort or use of effective strategies. That is to say, compared to non-LD students, LD students had greater maladaptive learned helplessness beliefs, but less adaptive control beliefs. When these adaptive and maladaptive composite scores were used in path analyses instead of individual subscale/attribution scores, a consistent trend started to emerge. Maladaptive attributional beliefs tended to have a direct negative influence on performance/achievement, whereas the positive influence of adaptive attributional beliefs on performance was consistently mediated through knowledge and the use of strategies. These relationships were observed in school-age students (Chan, 1994, in press-a; Ee & Chan, 1994; Youlden & Chan, 1994) as well as in university nursing students (Cholowski & Chan, 1994). It seems likely that although maladaptive attributional beliefs may have a direct detrimental effect on performance, adaptive
attributional beliefs are not sufficient to bring about better performance on their own: Each student must also have good knowledge and effective use of strategies. Adaptive attributional beliefs, or beliefs in personal control over task outcomes, serve the function of energizing the executive processes responsible for the regulation of strategies and, in combination, are likely to lead to better classroom- or laboratory-based performance.

Suggestions About Measuring Metacognitive Components

In the initial wave of research, the components of metacognition were measured in isolation. For instance, in the Kurtz and Borkowski (1984) study, knowledge about a set of memory problems reported by impulsive and reflective children was related to their transfer of reading strategies 3 years later; no intervening changes in other aspects of metacognition, such as the development of monitoring or control skills, that might have been associated with prior metamemorial knowledge, and perhaps causally related to the development of reading strategies, were assessed. This study illustrates the need to consider (and perhaps control) multiple aspects of metacognition when isolating and measuring any single component. We believe that three points need to be considered with reference to the context (and background information) necessary for the reliable measurement of the components of metacognition:

1. It may be impossible—or at least theoretically naive—to study the components of metacognition in isolation.
2. “Linkage” studies (e.g., relating strategy selection and attributions) may provide the best framework for theoretical validation as well as for achieving reliable measurements.
3. There is a clear need for research in which metacognitive constructs are interrelated from a developmental perspective. The relative importance of each component in the successful integration of the entire metacognition system probably changes dramatically with age (cf. Borkowski & Thorpe, 1994).

HOW LEARNING CONTEXTS INFLUENCE THE DEVELOPMENT OF METACOGNITION

It is possible to design learning contexts that influence attributional beliefs, motivational goals, and self-efficacious beliefs as well as the efficient processing of information, eventually resulting in deep con-
ceptual understanding. We believe it is essential to consider both contextual and correlated information related to the emergence of these skills and beliefs in order to develop reliable and valid measures of metacognition.

Parents and teachers—and the learning environments they create—are pivotal to the development of an integrated metacognitive system. The beliefs that parents and teachers hold about the nature of knowledge, and about the processes related to knowledge acquisition, play powerful roles in determining the design and outcome of instructional arrangements. These experiences also have implications for both the development and measurement of metacognitive skills and beliefs.

**Teachers’ Implicit Theories**

Teachers’ beliefs and implicit theories about how children learn can influence their planning of daily activities and, more generally, their teaching styles. For instance, Palincsar, Stevens, and Gavelek (1989) found a complex relationship between teacher beliefs and practice in the context of teaching reading skills: Teachers who conceptualized reading as a mastery of a sequence of isolated skills tended to require children to practice strategies in a routine fashion and were content-oriented in their conceptions of reading instruction. On the other hand, teachers who were more student-oriented, devoted more time to the affective and oral language dimensions of reading instruction and, important to metacognitive development, encouraged the flexible use of strategies. The “working model” presented by Borkowski and Muthukrishna (1992) suggests that teachers entice their students to become active participants in their own learning. Because the focus of instruction is always on the child’s personally initiated learning process, the instructor needs to become adept at hypothesizing how the learner is processing information at any given moment and to adapt instructions appropriately.

In problem-centered learning contexts, as described by Muthukrishna and Borkowski (1995), Cobb et al. (1991), and Olivier, Murray, and Human (1992), teachers become committed to the belief that students need to regard mathematics, in part, as a self-constructed activity. That is, they and their classmates can learn to discover new ways to solve problems if only they make the effort to think about the subject matter and work hard in understanding problem complexity. The teacher must regard himself or herself as the critical mediator in this instructional process, designed to interre-
late key metacognitive components: skills, knowledge, beliefs, and executive processes.

The teacher makes possible maximum task involvement by prompting students to collaborate with one another in order to gain deep conceptual understanding. Teachers' behaviors include verbalizations such as, "What do you think of what Peter just said?" "Do you agree/disagree with what Joanne said?" "Has anyone solved the problem a different way?" These verbalizations require process-oriented answers and help students to develop self-regulatory capabilities, such as monitoring, checking, and reflecting. Teachers also help students feel that they can assume personal responsibility for their own learning, by prompting them to explain and justify new solutions, resolve conflicts, and develop productive small-group relationships.

Motivation and Strategic Processing

Many researchers have argued that an understanding of motivation depends on the specification of achievement goals towards which individuals are oriented (Ames & Archer, 1987; Dweck, 1989; Dweck & Leggett, 1988; Nicholls, 1984). The achievement goal framework integrates cognitive and affective components of goal-directed behaviors. An achievement goal defines an integrated pattern of beliefs, attributions, and affect that underlies academic behavior and is represented by different ways of approaching, engaging in, and responding to achievement-related activities (Ames, 1992).

Nicholls and his colleagues (Nicholls, 1984; Nicholls, Pata schnick, & Nolen, 1985) have identified three types of motivational orientations towards school learning. Task orientation involves a commitment to learning for its own sake: The goal is to increase understanding, to accomplish something not previously done, and to improve performance. In other words, a task orientation implies that the process of learning, including the effort involved, is an end in itself.

Task-oriented individuals strive to learn and understand, and the more they see that they have mastered a task the more competent they feel (Nicholls, 1984). With an ego orientation, the aim is to perform better than others or to establish that one's ability is superior to another's. In this case, learning and understanding are viewed as means to the end of establishing superiority over others. Evidence presented by Nicholls (1989) shows that these two dimensions are uncorrelated, or only slightly associated. The third motivational orientation, work avoidance, involves a desire to put forth as little
effort as possible; work avoidance is negatively related to task-orientation.

The dimensions of task orientation and ego orientation relate to students' beliefs about the causes of academic success. Thus, different achievement goals should be associated with different attributional beliefs. Nicholls, Cheung, Lauer, and Pataschnick (1989) have suggested that if students are committed to outperforming their peers, they tend to believe that superior ability or attempts to do better than others are the causes of their successes in school. Similarly, the more task oriented an individual, the more that individual believes that success in school depends on effort, interest, and attempts to understand. Whether students are oriented to one goal or the other has consequences for whether they develop a sense of efficacy and a willingness to try hard and to take on challenges, or whether they select easy tasks and give up in the face of failure. In an important paper, Ames (1992) drew attention to the need to explore how the structure of learning environments can emphasize different motivational goals and, consequently, influence how students think about themselves, their ability, their peers, and how they and their peers approach problem solving tasks.

Muthukrishna and Borkowski (1995) analyzed how a problem-centered learning environment, compatible with socio-constructivist theory (Cobb et al., 1991), may help alter existing patterns of motivational goals and beliefs as well as produce more desirable strategies. The teacher created a "sense-making atmosphere" in which mathematics was seen as a meaningful activity. The learning context fostered task orientation and the belief that success depended on attempts to make sense of the subject matter. Students were made to see that they themselves could discover ways to solve problems if only they made the effort to think about them and worked hard to understand them. Results revealed that students exposed to the problem-centered contexts rated the task-oriented goal of understanding and collaborating more highly than students in a direct explanation of strategies condition. The belief that success in mathematics derives from attempts to understand and collaborate also distinguished the problem-centered group from the direct-explanation group. Relatedly, students in the problem-centered condition reported greater use of deep-processing strategies than students in the direct-explanation group and tended to show greater evidence of strategy use on a long-term "far transfer" task. One can infer that students whose primary goal is learning for its own sake will value and use strategies that require deep processing of information. If
students are encouraged to explore and trust their intuitions, they will have a feeling of control and develop an excitement about searching for meaning and understanding—processes that promote the generalization of skills and strategies across time and settings. After all, it was in large part, to solve the problem of skill generalization that inspired the development of metacognitive theory.

Similarly, Lampert (1988) has described a research and development project in teaching mathematics that demonstrates how it is possible to foster the simultaneous construction of meaning in mathematics, task-orientation as a form of motivation, and the deep processing of information. Lampert used a lesson to demonstrate how a teacher might model a new form of social interaction that would encourage arguments among students who were learning to examine hypotheses about the mathematical structures underlying their solutions to problems. In her lessons, she presented students with problems, but did not explain how to arrive at the answers. The questions she expected of her students went beyond simply determining whether they could arrive at a correct solution. Students were expected to answer questions about the legitimacy of the strategies they had used in problem solutions. Questions were process-oriented and required students to explain and defend their strategies. In this way, Lampert stressed that strategies used for figuring out a problem were as important as the answers themselves. The role of the teacher was to engage all students in the class in forming and testing mathematical hypotheses. Lampert (1988) found that these hypotheses were embedded in the answers that students gave to a problem, and that comparing answers actually engaged students in a discussion of a wide range of hypotheses.

Collaboration in Knowledge Construction

The characteristics of learning tasks and classroom activities can have profound influences on strategy-based learning and motivational orientations, such as students’ initiation about the requirements of various problems as well as the intensity and persistence with which they pursue them. Recent instructional innovations emphasize the need for students to be provided opportunities to construct knowledge and to engage in generative rather than passive learning (Brown & Campione, 1990; Bransford et al., 1990; Cognition and Technology Group at Vanderbilt, 1992; Pressley, Harris, & Marks, 1992; Schoenfeld, 1992). Learning as a social process and as a collaborative activity in pursuit of knowledge construction needs to
be stressed. In this view, children should engage in argumentation and reflection as they use and refine their existing knowledge in order to make sense of alternative points of view and to add to their knowledge base. A critical factor is that a truly collaborative learning environment demands reflection by the learners. Students are obligated to reflect on the meanings they construct and share in collaborative groups. Reflection induces an on-line awareness of one's cognitive processes, which promotes the development of self-regulatory skills. By expressing ideas in public, by defending them in the face of questions from peers, by questioning others' ideas, students are forced to elaborate, clarify, and reorganize their own thinking processes, contributing to the emergence of the kind of advanced cognition described by Butterfield et al. (1995).

In the "communities of learners" environment designed by Brown and Campione (1990), the aim is to produce "intelligent novices." According to these authors, intelligent novices have "learned how to learn" rather than just to memorize facts. Intelligent novices, therefore, presumably possess a wide repertoire of strategies for gaining new knowledge. A community of learners is jointly responsible for creating knowledge as well as a learning environment that is designed to foster the development of problem solving, critical thinking, and reflective analysis.

From our vantage point, the common thread in the learning environments of Brown, Bransford, and Schoenfeld and their colleagues is that learning occurs within an active social context that promotes the emergence of executive processing skills and positive beliefs about self-efficacy. Classrooms that emphasize socially based learning differ from traditional classes in several important ways: (a) students take on more active roles in monitoring their own progress as well as that of others; (b) teachers serve as models of active learning and guide learning rather than adopting a domineering, didactic role; and (c) the content emphasis is on deep understanding rather than on acquiring a breadth of facts.

Similarly, Schoenfeld (1992) has argued for a particular agenda in order to develop classrooms that are "microcosms of mathematical sense-making" (p. 82). His problem-solving courses at the college level appear to have as their major focus the development of self-regulation, especially monitoring and control skills, as well as the development of self-directing motivational beliefs. The approach is to prompt students to monitor their solutions carefully, pursue interesting leads, and to abandon those that do not seem to result in success. Students’ ability to monitor and assess their "on-line" progress, and to act in response to these assessments, are core components of self-regulation.
The instructor's job is to shape and structure classroom interactions (Schoenfeld, 1992). The shaping process consists of working on ideas generated by students themselves, with the teacher serving as a moderator for class discussions. A vast amount of the time is spent on collaborative efforts, either in small groups or as a whole class. Time is spent in actually doing mathematics. That is, students are engaged in the discipline, debating, conjecturing, proving, agreeing, and disagreeing. The focus is on deep levels of understanding and in enhancing positive attributional beliefs. The teacher serves as an external monitor during problem solving, encouraging discussion of behaviors considered important for the internalization of metacognitive skills, as well as a model of good executive behaviors. The hoped-for result is an increase in planning, monitoring, and active problem solving among the students.

Selecting Learning Tasks

Learning environments need to be structured so that students perform tasks that are related to interesting and coherent goals, rather than for extrinsic reasons. It is difficult to teach students to be strategic, to plan and to be cognitively alert when they are working on meaningless activities. In addition, the active use of knowledge is made clear, rather than obscured, when learning goals are personal and valuable. Brown, Collins, and Duguid (1989) have stressed the importance of "situated learning" in which knowledge is learned in the context of meaningful goals. Decontextualized forms of instruction are to be avoided. For instance, in the reading program developed by Palincsar and Brown (1984)—referred to as reciprocal teaching—comprehension monitoring strategies, such as summarization and questioning, are modeled and practiced in a context in which participants share the goal of gaining meaning from the text. The fact that students learn to apply comprehension strategies as they are being acquired is thought to be the key to the program's success. Situated learning has a great impact on the motivational orientations students develop. Activities become more meaningful because they offer personal challenges, provide students with a sense of control over the task at hand, and create an intrinsic purpose for learning. Ames (1992) believes that if students perceive meaningful reasons for engaging in an activity, they are more likely to espouse a task-oriented goal.

Presenting learning tasks as problems to be solved rather than facts to be learned can encourage richer and more elaborated process-
ing of information, especially if this is done collaboratively. In many classrooms, however, problems are typically of a “closed” nature, and difficult for collaboration. Problems of an “open” type provide opportunities for students to share different perspectives, hypotheses, and solution paths, as well as to engage in critical analyses. Such activities influence the emergence of executive skills as well as develop positive motivational goals.

Student Perceptions of Their Learning Environments

Students need to learn that classroom activities typically require them to work hard to achieve understanding. The classroom environment must be perceived as one in which they are free to explore ideas, ask questions, and make mistakes. They should learn that it is possible, even probable, to understand what one is doing and to come to the realization that it is worthwhile and rewarding. Such an environment contributes to the emergence of short- and long-term academic and occupational possible selves (Day et al., 1992). Ames and Archer (1988) and Maehr and Midgley (1991) have argued that such visions and beliefs are likely to develop when students are involved in choice and decision making, when there are opportunities for peer interaction and cooperation, and when success is defined as much by effort and improvement as by “correctness.”

Students’ perceptions of how their responses are evaluated influence how they approach tasks and result in the development of stable orientations towards motivational goals. Brophy (1983) characterized traditional classroom learning as highly product-oriented. In contrast, there should be an emphasis placed on thinking processes: Students learn that they have a need or an obligation to process information at a deep level because they might have to explain and defend their solutions to themselves and to others.

Students must recognize that their individual ideas become of greater value when placed in a social setting. Each student is not compared with others but rather is encouraged to jointly construct meanings and solutions to problems within a social context. Peers should be seen as sources of information, rather than as threats to self-esteem. Social comparisons, when they occur, are a critical factor affecting students’ perceptions about themselves, others, and the tasks per se. Ames (1992) found that students’ self-evaluations of their ability are more negative when classroom structures emphasize winning, outperforming others, and surpassing normative standards. Social comparisons in a classroom setting can have negative conse-
quences for student interest (Deci & Ryan, 1985), pursuit of challenging tasks (Elliot & Dweck, 1988), and use of learning strategies (Ames, 1992). Relatedly, Graham and Golan (1991) found that a focus on social comparison standards can interfere with effort-based strategies that require reflective, deliberate processing. In short, collaborative-based learning seems to enhance the development of the full metacognitive system.

SUMMING-UP

It is likely that the search for domain-specific or domain-general laws about metacognition, which up to this point in two decades of research have favored the former, will likely continue to be the core issue in metacognition research and measurement. However, both intuitive appeal and scholastic relevance favor the generality side and will continue to influence the direction and style of research in this field. We suspect that the data will eventually reveal selective generality (perhaps in an executive process such as task analysis); an intricate pattern of developmentally related events necessary for achieving generality (involving consistency in metacognitively based instructions in the home and school over long periods of time); and a complex blending of specificity and generality across individuals. Not all students who have relatively similar environments will show generality and those who do may also have relative strengths and weaknesses in one and the same metacognitive component across domains. For instance, a student may be high in a variety of monitoring skills but superior in monitoring memory accuracy. Given the early stage of theory development as well as the lack of measurement sophistication that characterizes this field, it is not surprising that the search for across-tasks and across-domains generalization of metacognitive components has remained an elusive goal. Consistency in home and school instructional environments appears as the major prerequisite for developing generalized metacognitive skills and beliefs. In this sense, our discussion of the nature and quality of learning environments takes on special significance for achieving high levels of metacognitive development and stability.

Classroom environments and experiences should show each student that he or she can gain control over their own learning outcomes if they adopt self-regulatory strategies. Teachers must continually encourage students to evaluate and monitor their problem-solving initiatives. This recommendation is supported by data of Paris and Winograd (1990) who found that students will apply self-regulatory
skills if they feel that they are able to manage their own learning. Perceptions of control affect motivational, regulational, achievement processes, and outcomes as well. Finally, Grolnick and Ryan (1987) concluded that conceptual learning appears to be facilitated by contexts that minimize external controls, and at the same time focus students on the task by encouraging deep processing. Thus, students’ perceptions of activities and tasks not only influence how they approach learning, but also their judgments about their ability, willingness to apply effortful strategies, and feelings of satisfaction—all of which contribute to skill-based learning.

It is not surprising that challenge, interest, and perceived control are embedded in the structure and design of problem-centered learning contexts (Muthukrishna & Borkowski, 1995). In such contexts, activities are structured as problems to be solved by all students, assisted by ample guidance, facilitation, and modeling from the teacher. Problem-centered, collaborative environments offer personal challenges and, over the long run, help students gain a sense of control, together with the emergence of task- rather than ego-orientations. Most importantly, such environments hold the potential for creating an intrinsic love of learning, housed within a mature and stable metacognitive system that yields to reliable assessment and, more importantly, gives reality to the idealized model of the “Good Information Processor” (Pressley et al., 1990).

REFERENCES


Lampert, M. (1988). The teacher's role in re-inventing the meaning of mathematical knowledge in the classroom. In M. Behr, C. LaCampagne, & M. M. Wheler (Eds.), Proceedings of the Tenth Annual Meeting of the North American Chapter of the International Group for the
1. PROCESS-ORIENTED MODEL OF METACOGNITION

Psychology of Mathematics Education (pp. 433-480). DeKalb, IL: Northern Illinois University.


