# LEARNING AND MOTIVATION IN THE CLASSROOM

*Edited By*

SCOTT G. PARIS
GARY M. OLSON
HAROLD W. STEVENSON

LEA

# 3 Child as Coinvestigator: Helping Children Gain Insight into their own Mental Processes

Marlene Scardamalia
*York University*

Carl Bereiter
*Ontario Institute for Studies in Education*

This chapter is based on a simple premise—that children's metacognitive development may be aided by giving them greater access to data arising from their own cognitive processes. It seems to be generally agreed that children are less aware of their cognitive processes than adults are (Brown, 1978; Flavell, Speer, Green, & August, 1981; Flavell & Wellman, 1977; Paris & Lindauer, 1982). Certainly one important factor retarding the growth of metacognitive knowledge is the limited availability of data from which such knowledge may be constructed. Not only are the data elusive because of the rapid and fleeting nature of mental events, but also because when people are engaged in mental activity their attention is normally taken up with the task at hand or with the content of cognition rather than being directed toward the process itself.

We are assuming, as others have (Brown, 1977; Flavell, 1979; Paris, Newman, & McVey, 1982), that metacognitive knowledge must be constructed like any other kind of knowledge. Insight into one's own mental processes does not occur because of a window opening on the mind but because in the course of long experience one manages to piece together some kind of coherent knowledge on the basis of fragmentary data.

A corollary to this premise is that not all experiences are equal in their ability to provide data for the construction of metacognitive knowledge. Activities may differ not only in the kinds of cognitive processes they elicit but also in the extent to which the cognitive processes that are brought into play yield instructive data. Let us consider an obvious example. The person solving a problem silently and the person solving a problem while thinking aloud are carrying out some of the same cognitive processes (no need to argue that they are altogether the same).

The person thinking aloud, however, generates data that cognitive researchers will often find to be more informative than the data yielded by the silent problem solver (Ericsson & Simon, 1980). Is it not reasonable to suppose that thinking aloud might also yield data helpful to the thinker in understanding his or her own cognitive processes, bringing events to light that might otherwise pass unnoticed? Thinking aloud is one among a variety of ways that cognitive researchers try to get cognitive behavior to yield more informative data. In setting out to devise ways of giving children greater access to data on which they could base metacognitive knowledge, therefore, a good starting place might be the kinds of activities that have proved illuminating in cognitive research.

For the past 5 years we have been doing cognitive–developmental research on children's writing. The nature and findings of this research are not germane to this chapter and therefore are not discussed here. (See instead Bereiter & Scardamalia, 1982; Scardamalia, Bereiter, & Goelman, 1982.) What is germane is that in the course of some 70 experiments we have employed numerous methods for probing mental processes in young people, and a frequent side effect has been that the children themselves became actively interested in what the experimental procedures were allowing them to discover about their mental processes. For the most part we have employed experimental designs that permitted us to inform subjects about the purpose of the inquiry and to discuss matters freely with them as we proceeded. This allowed children, in effect, to participate as coinvestigators—to function not only as sources of data but as seekers and interpreters of data as well.

Involvement and enthusiasm have generally been high. Students who have not liked writing have nonetheless seemed to like analyzing the task and the process. We have consequently been led to think about possible educational uses of this sort of collaborative inquiry. The educational use we explore in this chapter is coinvestigation as a way of fostering metacognitive knowledge, considered as a type of self-knowledge. Coinvestigation might also have promise as a way of developing theoretical or scientific knowledge—we have exploited it for that purpose ourselves—but that is a different matter. In this chapter we are not concerned with promoting the kind of formalized knowledge possessed by the psychologist but rather with promoting the more informal self-knowledge that appears to constitute a natural part of intellectual maturity.

This is mainly a how-to chapter. It describes a variety of techniques that we have found helpful for getting children profitably involved in inquiry into their cognitive processes. In presenting these techniques, we do not presume at all to advocate a "method" or to promote an already developed educational program. On the contrary, we offer these techniques in the hope that they may be helpful to researchers and instructional designers who are exploring ways of assisting metacognitive development. We do not foresee courses in metacognition being taught in schools. Rather, we foresee that instruction in many areas of intellectual skill might be enriched by designing activities so that they bring more of the cognitive

processes out into the open where teachers and students can examine and try to understand them. The illustrations offered in this chapter come almost entirely from work on writing. It would remain for educators or researchers to devise comparable procedures in other areas. Finally, the techniques discussed in this chapter are only techniques for making data from cognitive processes more accessible. What is done with the data—what kinds of discussions, comparisons, analyses, and planning of further explorations might ensue between teacher and child—also remains an open question. Simply getting cognitive data out into the open where it can be dealt with is no small accomplishment, however, especially when the data in question come from children who have had little experience in contemplating or consciously regulating their mental processes. We hope that the development of techniques for bringing cognitive behavior out into the open will create educational possibilities of exciting and unforeseen kinds.

## WHERE COGNITIVE INQUIRY MAY HELP

It is possible to agree with the points made in the preceding section and nevertheless question the advisability of encouraging children to focus attention on their own cognitive processes. We trust that some of these concerns will be allayed as we offer concrete examples, and so we reserve to the final section discussion of the overall merits of cognitive inquiry by children.

The ensuing discussion may be clarified, however, if at this point we consider how cognitive inquiry relates to more typical approaches to the teaching of intellectual skills. Most intellectual skills, after all, are taught reasonably successfully without any need for the learners to investigate what is going on in their own minds. Most of us probably have very little idea of how we read, for instance, and we probably had even less idea at the time we were learning; yet we do not feel that our capacity for intelligent reading has been hampered. Apparently, through practice and self-monitoring, we gain sufficient insight to hold us in good stead.

Not everyone acquires effective cognitive strategies for reading, writing, problem solving, and the like, however (Bereiter & Scardamalia, in press a; Flavell et al., 1981; Paris & Myers, 1981). The normal processes for aquiring procedural knowledge may be reliable for attaining the rudimentary skills of literacy and other major types of cognitive behavior, but they do not appear reliable for acquiring the strategies that characterize expert performance. The normal processes of acquiring procedural knowledge or "know-how" include observation, practice, and rule learning. The conditions under which we believe inquiry into cognitive processes is likely to prove valuable are the conditions in which these typical methods are not sufficient. Let us consider briefly what those conditions might be.

## Observational Learning

Strategy learning through observation has been frequently demonstrated (Rosenthal & Zimmerman, 1978). Strategies themselves, being mental phenomena, cannot be observed, of course. Behavior is observed and the strategy must in some sense be inferred. The problem with many cognitive strategies is that observable behavior gives only a limited and sometimes misleading basis for reconstructing the underlying mental operations.

An anecdote provided by a colleague illustrates the problem. Her young son one day announced that he had learned to revise. He proudly showed her an essay with sentences crossed out and with arrows directing the reader to insert chunks of text and to reorder different parts. The trouble was that the revised draft did not make sense, so she asked her son what he was trying to accomplish. What he was trying to do was make his papers look like a manuscript she was working on. He mimicked the observables of the revision process but not the accompanying mental operations that gave purpose to the observables.

We should not underestimate the value of such observational learning. It provides a concrete framework to which the more elusive mental operations may be attached. Thus, we would expect this colleague's son to be at a considerable advantage compared to many young students with whom we work, whose only concrete model for revision is the producing of a clean copy. Observational learning may also be helpful in creating a motivational context for cognitive strategy learning. Although not yet grasping what revision was for, our colleague's son must have sensed that it was a valued activity and one worth emulating. Similarly, children who observe their parents reading may not thereby learn much about the process of reading, but they are likely to learn something about its place in life.

As we see it, the observable manifestations of cognitive behavior provide an excellent starting point for coinvestigation of the process, for adult and child to discover, for instance, what is different in the ways they decide what to cross out and where to draw the arrows in revising a manuscript. But if children are left too much on their own to fill in the mental activities lying behind observables, there is a danger that they will remain dominated by what they observe. Thus, in writing, we find children's composing processes to be dominated by the observable part of the process—the manuscript. When asked to plan texts aloud, they yield protocols that are little different from what we receive if we ask them to dictate essays (Burtis, Bereiter, Scardamalia, & Tetroe, in press). Expert writers, on the other hand, display a large and varied amount of thinking during composition that is relevant to but never appears as part of the manuscript (Hayes & Flower, 1980). In order for children to grasp these other kinds of thinking, they need sources of information beyond ordinary observation.

One of the ways that instructional researchers have tried to overcome the limitations of ordinary observation has been by rendering more of the cognitive process observable, often through the use of thinking aloud while modeling

(Bird, 1980; Brown, 1978; Burtis et al., in press). Studies so far reported all seem to indicate that cognitive modeling, unless it is supported by more active instructional procedures, is not effective in changing children's strategies. As we shall see, however, thinking aloud by both child and adult can provide a valuable source of data for use in coinvestigation of cognitive strategies.

## Practice

Groen and Resnick (1977) have shown that through practice alone young children develop increasingly sophisticated strategies for simple addition, moving from laborious finger counting to methods using increasingly efficient mental operations. A necessary condition for practice to be sufficient is a large amount of redundancy in operations and content. It is the repeated counting of the same small set of numbers, Neches (1979) suggests, that creates the possibility of discovering shortcuts.

Every skill has its redundant elements. The danger in relying on practice alone is that the redundant parts will be worked into a streamlined procedure that is insensitive to novel or nonredundant aspects of the activity. Singing, for instance, is highly redundant. One sings the same limited set of notes with the same limited set of durations over and over again in various combinations. With practice one can become proficient at this. But singers who are serious musicians must struggle continually to rise above the effects of mere practice and to perfect ways of singing that are attuned to the distinctive qualities of each composition. This requires both effort and insight (Pavarotti & Wright, 1981). Effort and insight mark the ways in which *studying* singing is different from simply practicing it.

We have reason to believe that what is true of singing is also true of such intellectual skills as reading and writing. Here, too, there is much redundancy, so that with practice students can develop efficient strategies that allow them to meet the routine demands of school reading and writing tasks with a minimum of effort. The result, however, is comprehension strategies that are insensitive to the distinctiveness and complexity of text information (Scardamalia & Bereiter, in press c), and writing strategies that are insensitive to the distinctive requirements of different writing goals (Bereiter & Scardamalia, in press a). Rising above these routine "cognitive coping strategies," as we call them, requires sustained effort directed toward one's own mental processes. Prime candidates for coinvestigations with children, then, are skill areas in which "practice makes perfect" is an untrustworthy slogan.

## Rule Learning

Strategy learning can be greatly simplified whenever students can be taught rules that they are able to follow. Not all rules that describe expert performance are followable by novices, however. Consider the following rule of writing style, for instance:

Omit needless words (Strunk & White, 1959).

It seems likely that anyone sophisticated enough to be able to apply this rule would not need to be taught it.

One may, of course, strive for simpler or more explicit rules, but there will surely remain many cases in which children lack the knowledge necessary to apply a procedural rule and cannot be readily taught it. An alternative in such cases is to teach children a self-regulatory procedure that permits them to make optimum use of the knowledge they do possess. For editing out "needless" language, for instance, children may be taught to experiment with deletions, testing to see whether meaning is disrupted by the deletion (Bereiter, Scardamalia, & Cattani, 1981). Coinvestigation is relevant in these situations because the procedure does not depend on the children's conceptual understanding of rules but rather on their ability to direct and monitor their cognitive processes.

Overarching all the problems we have been considering is the problem of motivation or purpose. In the case of highly specific skills such as high jumping or playing chess, learners can have from an early stage a fairly clear idea of what they are trying to achieve. If they are motivated to achieve it, then they will likely make the most of the opportunities offered by observation, practice, and rule learning, and show progress to more sophisticated strategies even when the learning conditions are far from ideal.

In the case of more general intellectual skills such as comprehension, composition, and explanation, however, students who have not yet achieved a sophisticated strategy are not in a good position to appreciate what the strategy could do for them. With these kinds of activities, the goals tend to emerge from strategy execution rather than to precede it (Scardamalia & Bereiter, in press d). Consequently there is a serious motivational problem, not in the sense of students' unwillingness to exert effort but in the sense of their not having a clear notion of what their efforts are supposed to yield. In the absence of such a notion, it is natural for students to stick with the cognitive strategies they have and to assimilate new learning to them. We have repeatedly found that our efforts to guide students to more complex composing strategies are thwarted unless we can convey to the students some sense of a cognitive outcome to strive for. Coinvestigation of cognitive strategies has so far appeared to have its most significant function in this motivational context. It gives children an opportunity to grasp the potentialities of cognitive strategies that they have not yet mastered, and this allows them to engage in strategy learning activities with a greater sense of purpose.

## OPEN INQUIRY

The techniques discussed in this section are general-purpose techniques for bringing cognitive events out into the open in working with children. Although

children may be as mentally active as adults, and often even more willing to expose their mental activity to scrutiny, it is usually more difficult with children than with adults to bring forth information on their cognitive processes. This is partly because children are less accustomed to paying attention to their mental processes and consequently lack some of the metacognitive skills needed to extract metacognitive knowledge. Also, they lack the large repertoire of mentalistic terms that the sophisticated adult possesses, and this limits their ability both to understand questions and to formulate statements related to cognitive events. This does not make cognitive inquiry with children any the less rewarding, either for the adult or for the child; it only means that the adult must come equipped with appropriate techniques for helping children surmount the obstacles to inquiry and communication.

The simplest way to engage children in collaborative interchange is to have them introspect—simply talk to you about how they typically do something or try to monitor their mental activities as they engage in some activity. In our experience with such techniques, major difficulties in employing them come not so much from limitations in what children can contribute, as from the adult's misunderstanding of what the child can be expected to contribute.

It is true that the child cannot keep up as active an interchange as an adult coinvestigator can. Adult coinvestigators have a good deal of sophistication in making points clearly, coming back to points not made clear on first go-around, noting when there is a mismatch between what has been conveyed and what is intended, and so on. A rule of thumb we seldom find ourselves regretting having followed is to assume that when a child is telling us something that seems either insignificant or very confused, we are probably missing something important. Also, the child is probably struggling to explain something at the edge of current awareness. This is precisely the point at which we must try harder to make sense of what is happening.

What follows is a list of techniques for supporting discussion under such circumstances. Before proceeding with this list, however, a list that might make it appear that the adult is not assuming the role of coinvestigator so much as the role of coach, we would like to clarify the sense in which the effort is a collaborative one, with mutual benefits for investigator and child.

It is important to remember that the adult is involved in the first place because the kinds of complex activities being dealt with are not well understood. If the adult knew the procedures underlying the phenomena in enough detail to model them clearly or reduce them to specific rules, then the problem would not be so difficult. The truth of the matter is, however, that adults are novicelike in this respect and are trying themselves to understand procedures being used. In interchange with children we typically start by explaining that our purpose for being there is that we would like to learn more about how people write. It is precisely because this process is not well understood that we seek their help. We believe they have important knowledge to contribute about how children their

age do things. The message is a sincere one, because it is true, and it establishes their legitimacy as coinvestigators. We remind the reader that our concern here is with bringing cognitive phenomena out into the open so that they are available for discussion by adult and child. We do not deal with the inferential processes that may go on in such discussions nor with the scientific uses to which the resulting information might be put (see, however, Bereiter & Scardamalia, in press-b).

a. *Teach Children to Think Aloud.* The purpose behind teaching the child to think aloud is that the thinking-aloud experience itself provides data for comment. That is, it appears to make normally covert processes more accessible to the person doing the thinking aloud, as well as to the person listening.

However, we have found that young children find thinking aloud a more difficult task than adults do. Adults, asked to say aloud all the things that naturally occur to them as they engage in some task, can proceed with little additional instruction. In contrast, younger children tend to need someone beside them to provide encouragement and to ask questions when they fall silent (see sections d and e). Practice also seems to help, as does learning to think aloud while doing some nonverbal activity such as drawing a picture.[1]

The rewards of engaging students in think-aloud experiences are substantial. The following discussion took place in a class of Grade 10 students who had just completed one session of thinking aloud while reading. First one student put up his hand: "I think that when you have to read out loud you slow down the whole process of reading. I read much faster when I read to myself. Don't you think that if information goes into your head faster that better things might come out?" This child seems to have some insight into the concept of coding efficiency as currently represented in the literature (Perfetti & Lesgold, 1977). Another student put up her hand in response and said: "Well, I think it's not the speed that's the big thing. I think it's the fact that when you make me say everything out loud I'm using up a lot of what's in my head to do the job of thinking aloud so I don't have so much [mental working space] left to do the thinking about what I'm reading." (This student appears to have some insight into limited capacity information-processing models). Another student, in a tone suggesting embarrassment, confessed: "I have a problem. When I read, I like to read the last paragraph first. That way when I start again from the beginning, I have some idea of what's going to happen." She seemed delighted to discover that we thought her strategy was a sophisticated one, and other children seemed interested in the possible advantages and disadvantages of this strategy.

The point of these examples is not that students have sophisticated ideas about

[1]The use of nonverbal tasks in series with verbal tasks was investigated by Tetroe (1981).

cognitive processes, although they sometimes do. The point is that they are very interested in analyzing their cognitive processes, and that they are interested in them in much the same way as cognitive psychologists are. On the toughest of teaching days we find children will give us their full attention if either another student or the teacher engages in some thinking-aloud activity.

b. *Give Students Something Concrete to Talk About.* Vague questions such as "How do you decide what to write when you're given a writing assignment?" are likely to result in vague or stereotyped answers. We find, in fact, that questions of this broadly "metacognitive" kind make for a tense interview. The student wants to be cooperative but is never quite sure what you are trying to get at. It is much better to give the students something to do—moving things, underlining, searching, etc.—and then discuss what they are doing as they do it. In studying text comprehension, for instance, we have found that a task of arranging sentences provides the basis for a richer discussion of comprehension strategies than does ordinary reading, because the task involves discrete decisions that can be questioned and justified (Scardamalia & Bereiter, in press c).

Hayes-Roth & Hayes-Roth (1979) have a task they use to study planning that illustrates the advantages of tasks that are not strictly dependent on verbal report. Subjects are provided with a shopping list and a city map and are asked to plan a day of shopping where they try to accomplish a great number of things in a limited time. The nice feature of the task for purposes of uncovering planning procedures used by young children is that their planning strategy shows up concretely in the way they track things on the map and refer to the shopping list. What an experimenter can see from observing such activity is that adults get themselves oriented to the map as a whole, determining sections of the city where with little travel they can get much accomplished (Hayes-Roth & Hayes-Roth, 1979); by comparison, young children get themselves located at one point on the map, see if the building next to it is one where they can accomplish any one of the specified tasks; if not, they move to the next building and repeat the same procedure. Planning, with this task, becomes something like a board game, making it possible to discuss and compare strategies as one might, for instance, with a game like checkers.

Tasks that manage to uncover strategies for adult investigators tend also to provide children with data they need to understand their own activity. Children frequently can describe their activity *after* such an exercise, although they would not do so before. Further, seeing an adult do the task after they have themselves had the opportunity to "see" how they perform, appears to create interest in and appreciation of the adult strategy.

In one study (Bereiter, Scardamalia, & Turkish, 1980), we wanted to investigate children's conceptual knowledge of written genres. Questions like "What kinds of things would you include in a story?" obtained results from high school

students, but elementary school children did not know what to make of the question. In this case giving them an actual story to talk about would only serve to focus attention on specific story content rather than on general properties of the genre. What finally worked was to show them an actual composition but not let them read it, saying, for instance, "This is an essay I wrote trying to convince somebody of something. What kind of thing do you think I probably said at the beginning, in order to make this a good essay?" Although getting children to discuss abstract characteristics of text was still not easy, this minimal amount of concretizing at least made it possible.

c. *Have Students Prescribe Rather Than Describe.* Students who are inarticulate in trying to describe how they go about doing some mental task often come forth with clear statements of procedure when asked to give advice to another student, particularly a younger one, for carrying out the task. Even formulating instructions for themselves can be helpful, as Meichenbaum (1973) has shown. The benefits that peer tutoring has been found to yield for the child doing the tutoring (Cloward, 1967) may be partly due to this effect. Children seem to have a better vocabulary for prescribing than for describing. It is also possible that the task of prescribing gives better direction to their search of long-term memory than does a task of describing.

d. *Attend to Nonverbal Cues and Use Them as Points for Discussion.* Here are some examples of observable behavior and related questions:

| *Observable Behavior* | *Possible Question* |
|---|---|
| Eye shift | You just noticed something, didn't you? |
| Change in rate | You're going faster now. Is this part easier? |
| Discouraged look | You look discouraged. Is something particularly hard here? |
| Satisfied look | Did you just figure something out? |
| Long pause | What's going on in your mind now? |

e. *Enlist the Student's Help in Getting You to Understand.* When a child makes an unclear statement, novice interviewers tend to err in either of two ways. They either take the statement at face value, which means the child gets

classified as the one who doesn't understand, or they resort to courtroom procedures of insistent questioning, which often confuses or intimidates the child. In coinvestigation, however, adult and child should be trying equally to help each other understand what is going on.

We have found conversational moves like the following to be useful in getting students to take an active role in helping us to understand, rather than responding passively to the questions they are asked:

*Ask student to fill in gaps:* "You've lost me here. How did you get from thinking about *X* to thinking about *Y?* Did I miss something?"

*Ask student to restate more slowly:* "Wait, you're going too fast for me. Could you say that a little slower so I can write it all down?" (This often leads to restatement in different terms, yielding more clues for understanding.)

*Confess incomprehension:* "I just don't get it. If this is so hard that you can't do it, then how did you know to write down what you've written so far?"

*Check distortions:* "I think I got something wrong here. I wrote down _____ but I don't think that's quite what you said." (By getting a chance to correct misstatements children not only clarify what they said originally, but they begin to feel free about correcting the adult and consequently may begin to do so when the adult isn't aware of a need to be corrected.)

With all the foregoing statements, the essential thing to convey is that it is you, the adult, who has a problem with the verbal interchange—not the child. That is, you are failing to get some piece of information that you believe is quite important. When children clearly get this message we find them taking on more assertive roles, correcting the adult's misconceptions, asking the adult to rewrite something because it is not quite right, and we've even had children suggesting to us questions we might ask them if we really wanted to know what they were thinking.

f. *Use a Series of Tasks of Increasing Complexity.* . Because change is usually more salient than constancy, children can often gain awareness of cognitive strategy features by noticing what things get harder to do as a task increases in difficulty. The task sequence must be carefully designed, of course, so that changes are clear-cut and psychologically interesting. One would not, for instance, derive much from presenting students with a sequence of miscellaneous reading passages selected so as to be graded in readability level. They would differ in too many ways at once, and some of the major factors in difficulty, such as vocabulary, are probably not very fruitful ones for coinvestigation.

A simple task sequence that we found productive for studying composing processes was a sequence that involved planning a paragraph that would incorporate two given sentences (Paris, Scardamalia, & Bereiter, 1982). At the easiest level the two sentences contained common topical words. At an intermediate

level they contained related but not identical topical words. At the most difficult level the two sentences did not directly suggest a common topic at all, so that the student had to invent a unifying theme. Task sequences suitable for coinvestigation of cognitive strategies can be found scattered throughout the experimental cognitive–developmental literature; see for instance the balance scale tasks in Siegler (1981), and the equivalent fraction tasks cited by Case (in press).

For use in coinvestigation it is important that the tasks start at an easy enough level that the students can build confidence in their basic ability to handle the type of task, and they should if possible increase in difficulty by steps sufficiently fine that students can experience points that give them real difficulty, short of total failure.

Again, it is vital for children to understand that the point of the activity is not successful or unsuccessful task performance but rather understanding the mental processes involved in the task. Once children catch on to the idea that each step in task difficulty means an interesting new phenomenon to investigate, they seem to lose their anxiety about success and failure and can even begin to regard failure, when it comes, as itself an interesting phenomenon to be explained. A further possible benefit from this kind of activity is metacognitive awareness by students of their own capabilities, with an accompanying ability to predict what will and will not cause them difficulty.

g. *Turn the Task the Child Must Work on Into a Discrimination or Comparison Task.* Rather than requiring students to describe the strategies they use to solve a task, have them evaluate some strategy that you propose or demonstrate.

We have found three different presentation formats useful. Each assumes that the child has worked previously on the task and therefore has something to compare the adult's procedure with.

The first is the most straightforward. Simply think aloud while you do the precise task the child was just asked to do. Then ask the child if what you did was anything like what he or she did.

One child we had been working with struggled for a long time trying to figure out which of several stories fitted a particular proverb. His strategy, as far as could be determined from what he did, was to find a topic that the proverb and story shared, and match proverb to story on this topical basis (i.e., they are both about monkeys), rather than on the basis of underlying meaning. We then modeled how we went about the task, matching elements in the story with elements in the proverb and checking to see whether the story elements could fit into the proverb and still make sense. Upon seeing this (the strategy was not described to the child, the child just looked on while the adult talked aloud) the child proceeded to accurately describe the adult's strategy, compare it to his own, and consider how he might go about the task differently in the future. Prior to this the child had seemed neither to be able to describe his own strategy nor to appreciate what the adult was saying about how he might do things differently.

Another format is to lead students through the execution of a different strategy themselves and then have them compare it to what they normally do. This only works, of course, with procedures that are straightforward enough that one can coach students in carrying them out. But a variety of important cognitive strategies are of this kind, such as those involving rehearsal, review, apportionment of study time, and elaboration in memorizing (Brown, 1978; Paris et al., 1982; Rohwer, 1973).

The third format, easiest for the child, requires the most work on the part of the adult. The adult identifies cognitive procedures that the child appears to be using and puts these in a list along with other procedures that the child does not appear to use. Some of these other procedures reflect less mature strategies, some of them more mature strategies than the child appears to employ. This method has been employed by Paris and Myers (1981) to identify reading strategies. We have found it useful, from the child's point of view, for gaining insight into strategic choices related to more and less successful task performance. One child, for instance, had been working on revising stories to accommodate new information. When presented with a list of procedural rules, he could identify procedures he once followed but no longer did (keep the story the same and add the new information at the end), as well as identify useful procedures that he had not previously thought of (e.g., think of different ways the ideas already in your story and the new idea can fit together, then choose the one that makes most sense).[2]

The methods of open inquiry described in this section are all ones that can be used without any great deal of formal psychological knowledge. This fact naturally raises a question of validity. If one were proposing student inquiry in physical science, one would want to be sure it didn't result in the learning of a lot of wrong principles. What is to prevent coinvestigation of cognitive processes from resulting in a lot of false psychological knowledge?

False knowledge is not likely to be a problem so long as the responsible adult tries to keep attention focused on strategy description and evaluation, avoiding the temptation to formulate general laws about how the mind works. The cognitive inquiry we have been talking about is largely a matter of observing events and trying to relate them coherently to one another. Naturally the observing and the relating will both be limited, but that would be true for any other kinds of events. In discussing a field trip, for instance, students will have failed to see much of what was there to be seen, will have misperceived some things, and will interpret events in ways that reflect their lack of background knowledge and concepts. The teacher, furthermore, will often not be an expert in the area pertinent to the field trip. But those are not reasons to avoid field trips and much less are they reasons to avoid describing and discussing what was observed. On

[2]This procedure was devised by Sonja Dennis in course work at the Ontario Institute for Studies in Education, and the example is from her report.

the contrary, it is through just such experiences that one hopes to build the experiential basis that will give meaning to later, more disciplined study.

## MODEL-BASED INQUIRY

Techniques of open inquiry, such as those described thus far in the chapter, serve mainly as a way of putting children in touch with the cognitive strategies they presently use. A whole other dimension of metacognitive knowledge, however, is awareness of strategy change—being aware not only of one's current cognitive behavior but of developments that lie ahead. Again, some of this knowledge can be imparted by conventional means—by demonstrating or explaining more advanced strategies, for instance. Although these didactic approaches, if based on sound knowledge, can be extremely valuable, we believe the ideal circumstance for learning would be one in which students can actually experience strategy change. In other words, although it may be very useful to understand "This is how I do it and this is how an expert does it," a sizable increment in self-knowledge occurs if the terms can be shifted to "This is how I usually do it and this is how it feels to do it like an expert." Needless to say, such a foretaste of expert competence can also be expected to have a strong motivating effect.

But how does one get a child to experience expertlike performance, short of turning the child into an expert? The answer may lie in a technology that has only recently begun to take shape among instructionally oriented developmental psychologists—a technology that we have called *simulation by intervention* (Bereiter & Scardamalia, in press b; Brown & Campione, 1981; Butterfield, Siladi, & Belmont, 1980). In scientific applications, simulation by intervention involves testing theoretical notions about cognitive development by experimentally introducing either facilitations that the theory predicts will cause younger subjects to act like older ones, or impediments that the theory suggests will cause older subjects to act like younger ones (see, for instance, Case, Kurland, & Goldberg, 1982). Simulation by intervention thus requires a fairly strong model of the cognitive process under investigation, in order to have a basis for making and testing predictions.

Educational applications of simulation by intervention also require a fairly strong model of the process in question, which is why we have labeled this section "model-based inquiry." The idea is to intervene in children's typical cognitive processes in such a way as to induce cognitive behavior that formally resembles or contains significant elements of more mature cognitive behavior. Because students find themselves involved in mental activities that are new to them, the situation is a natural one for coinvestigation of cognitive processes.

In this section we discuss and illustrate three approaches to model-based inquiry. Whereas in the section on open inquiry we could discuss a variety of

detailed techniques that are applicable in a wide range of activities, model-based inquiry tends to require different techniques, depending on the model employed. Consequently the material in this section is intended mainly to suggest general ways of going about model-based inquiry.

a. *Induce a Simplified Version of the More Advanced Strategy.* This approach, known as procedural facilitation, is described at length in Scardamalia and Bereiter (in press d). The advanced strategy may be simplified by reducing open-ended decisions to choices among a few alternatives and by establishing routines that bypass certain difficulties. The child is helped to execute the strategy by the use of externalized procedures and cues. However—and this is a key point as far as coinvestigation of cognitive processes is concerned—the child still has to do all the productive thinking. Procedural facilitation simply helps to structure the process. Hence, children find themselves engaging in mental activities that are new to them, and this frequently fascinates them, providing a natural focal point for coinvestigation. By providing an explicit contrast to routine procedures such methods tend to highlight two kinds of data: (1) how one typically goes about the task—information that naturally arises out of the child's efforts to cope with changes forced by the new routine; and (2) the nature of more sophisticated performance—information that follows from what the routine enables the child to do that is in advance of normal procedures.

One of the most elaborate procedural facilitations we have tried was concerned with getting students to evaluate, diagnose, and revise their texts (Scardamalia & Bereiter, in press b). Normally, children's revision procedures consist essentially of proofreading. In the induced procedure, students used a simplified routine that involved making evaluations of their writing at the end of each sentence. They chose, from a diverse but small set of evaluative statements, ones that were applicable to their text, explained their choice of evaluations, chose from a small set of remedial activities an appropriate one, and then carried out the chosen action. The overall effect was that elementary students did make more adultlike revisions. Moreover, they unanimously reported that the procedure had taught them to do things they didn't normally do—consider the coherence of consecutively presented ideas, consider how an idea might confuse a reader—and to stop doing things they normally did. The procedure stood directly in the way of their carrying out typical revision activities of producing clean copy, and most children claimed it was the first time they had any idea *how* one might go about doing things in ways other than those they were accustomed to, even though they knew all along that they should.

The same principles of coinvestigation apply here as with the more informal procedures discussed in the preceding section. Purposes need to be open and shared. Students need to feel that the emphasis is on mutual understanding of the mental phenomena, not on successful performance. And the same methods for

achieving fruitful discussions are applicable. The difference is that procedural facilitation opens up rich possibilities for turning the spotlight of coinvestigation on mental growth itself.

b. *Use Tasks That Transfer Existing Strategies to New Domains.* In writing, as in a variety of intellectual tasks, children fail to evidence capabilities they evidence in more practical contexts. For example, although in their daily lives children clearly demonstrate planning toward goals, they rarely show evidence of explicit goal-directed planning in composition (Burtis et al., in press). There are some profound reasons, that we cannot go into here, why composition goals should be harder for children to get a fix on than many other kinds of goals (Scardamalia & Bereiter, in press d). But by altering the composition task somewhat, it may be possible to get students to apply their already existing abilities in goal-directed planning to writing.

A series of studies by Jacqueline Tetroe (1981; Tetroe, Bereiter, & Scardamalia, 1981) explored the possibilities of doing this by giving students ending sentences that it was their job to write compositions leading up to. Introducing this concrete kind of goal was, in fact, found to induce a higher level of planning (Tetroe et al., 1981).

In order for interventions of this kind to have a lasting effect, it seems essential that students gain as much insight as possible into what they are doing. Planning to reach an ending sentence is not the same as the planning mature writers do to achieve a rhetorical goal, but it has similarities that students may be able to recognize through discussion and reflection—through considering, for instance, why the ending sentence task is harder than the typical writing task and what it is that they do differently in coping with it. In this particular case the task enabled children to distinguish between their "what next" approach to text production—thinking of an idea and then considering what they should say next—and the strategy of considering multiple task constraints simultaneously—the strategy that writing to an ending sentence encourages.

An extensive collection of writing tasks that use concrete goals to mobilize strategies that students do not spontaneously apply to writing is presented in Scardamalia, Bereiter, and Fillion (1981). We are not aware at this time of other domains in which strategy-mobilizing or strategy-transferring tasks have been devised.

c. *Have Students Provide Procedural Support for Others.* In the "Open Inquiry" section we mentioned the benefits for cognitive inquiry of having students prescribe procedures for others. A more refined version of this approach is one in which children administer procedural facilitations to an adult or to other children. This approach has the significant advantage that it permits the child to participate in or actually to induce in someone else a cognitive strategy that the child himself or herself has not yet mastered.

We have tried this with children providing procedural support to someone else who is planning a composition. The child is provided with a list of sentence openers like "An even better idea is . . . ," "I could make my main point clearer if . . . ," and "But many readers won't agree that . . ." The child's task was to use these planning cues, as we call them, to help an adult plan a composition. The adult planned out loud and the child was to listen closely and hand the adult a planning cue whenever the adult was stuck or when it seemed appropriate to help the adult think harder or more completely about the composition. When handed a planning cue, the adult was supposed to start the next planning sentence (not text sentence) with it, if possible.

What we find consistently, even with children of age 8 who use this procedure, is such close monitoring of what the adult is saying that the cards selected at "stuck points" are those the adult might well have selected were she conducting the procedure herself. The data the child is made privy to under such conditions should serve both to illuminate the nature of mature processes and to provide the child with a means of entering into the mature process.

Children can be shown to produce thought judged more reflective than that produced by children not using the cards under conditions where roles are reversed—where the adult is handing cards to the child (Scardamalia & Bereiter, in press a). This suggests once again that, given insight into more mature processes, children will make use of that insight (see also Paris et al., 1982).

One distinct advantage of having a child provide procedural support for someone else is a division of mental labor. When students tried to use planning cues by themselves they usually found this more difficult. As one 11-year-old put it, "You've asked me to both think of ideas and to look at them at the same time! I can't do that. And if I think of the idea, then stop to think about it, I forget what I'm supposed to be thinking of." By dividing cognitive tasks and switching roles, students have the opportunity to see a process from different viewpoints and to avoid cognitive overload while doing so. They also get a picture of why the task they are being asked to do is so difficult.

Model-based inquiry clearly has advantages in directing inquiry toward the growing edge of the child's competence rather than toward the child's habitual practices. It is clear, however, that one needs to make strong assumptions about the nature of this growing edge and where it is growing to in order to design procedural facilitations and other model-based interventions.

Two concerns might occur to the reader. One is, what if the model is wrong? That is, what if the supposedly more mature strategy that we are trying to give children a feeling for isn't really the way mature people function but is instead some psychologist's mistaken idea of how they function? In our experience this problem has seemed to be self-correcting. If we try to persuade children to use a poorly conceived procedure, they either can't do it, find it silly or unnatural, or—which is most frequent—transform the procedure in such a way as to make it work within their existing strategies. Fortunately, a model-based procedure can

be satisfactory even though the model it is based on is only a very rough approximation. So long as the procedure leads children somewhere into the neighborhood of a more mature process, they can start to have experiences that open their eyes to possibilities for further growth and learning.

Another concern educators might have about model-based inquiry is that it seems to impose on children standard ways of doing things, whereas open inquiry gives scope to individual differences in cognitive strategies and styles. This might be a problem if we were talking about extended programs of instruction in which model-based procedures were engrained as habits. As it is, however, we are talking about their more episodic use as vehicles for exploration, insight, and novel experience. In this regard, we think it is vital to keep the inquiry aspect at the forefront of students' attention. They should never be told that the procedures they are experimenting with represent the *right* way to do things.

The procedures should not be treated as mere games or gimmicks, either, however. Students need to realize that they are experimenting with ways to extend their mental capabilities. They are not experimenting with neat tricks to make work easier, but rather with procedures that involve thinking more deeply about more things. In our experience students respond marvelously well to this kind of opportunity, provided they are supplied with procedures that enable them to act. It is being asked to think harder when they have no available means for thinking harder that makes students retreat from intellectual challenges.

## CONCLUSION

In the preceding sections we have presented a number of specific techniques whereby adult and child can collaborate in the investigation of cognitive activities. Our emphasis has been on techniques the adult may use to facilitate communication and to bring into the open the kinds of phenomena that will make coinvestigation fruitful. In concluding, however, we want to reemphasize the mutual nature of the investigative enterprise and take a broader view of its purpose.

One of the reasons that inquiry learning in the schools may not live up to the glowing words in which it has been advocated is that, for the most part, children are finding out things that the teacher already knows. The result is that the teacher can, at best, share vicariously in the children's curiosity and joy of discovery. At worst, inquiry turns into puzzle solving, where the teacher knows the answer and the children's job is to find out what it is.

Inquiry into people's own cognitive processes is a different story. Here, teachers and students can work as genuine partners in inquiry. Partly this may be because everyone is rather ignorant about how the mind works. But there is more to it than that. We have perhaps done more cognitive research on children's

writing than anyone else has or will ever care to, yet we have experienced no decline in the amount of new insight we can gain by sitting down with a child and engaging in one of the kinds of shared inquiry described in this chapter. Quite the contrary. The more we understand the composing process, it seems, the more we can learn and the more we can help a child to learn.

The crucial thing seems to be that we are learning about ourselves (and we, the experimenters, always are learning about ourselves in coinvestigation, as well as learning about the children—and the children, also, are learning about us as well as learning about themselves). Understanding of self and others appears to be nonterminating, and this is probably because it aims to be holistic. Consequently every new detail is a potential challenge to our understanding of the whole.

The principal value that we see in acquiring personal (as contrasted with theoretical) knowledge of cognitive processes is that it enables students to take a more self-directive role in their mental development. Cognitive development in young children is largely unintentional. As Montessori (1967) pointed out, the young child does things that result in learning, but does not do them in order to learn. Cognitive development is a natural consequence of activity carried out for other purposes. The child's actions may be driven by curiosity, but the curiosity is "aroused" by external events. Later we begin to see the emergence of what we have elsewhere analyzed in detail as *intentional cognition* (Bereiter & Scardamalia, in press c).

In its largest sense, intentional cognition means having a *mental life* that is carried on consciously and purposefully, just as one's outer life is, but that is not simply a projection of that outer life. Rather, mental life has purposes and activities of its own, which are primarily concerned with the active construction of knowledge.

Perhaps the most far-reaching consequence of developing a self-directed mental life is that meaningfulness ceases to be a property that is "found" or not "found" in external activities and contexts. It becomes a property that people invest activities with, by virtue of assigning them a role in their mental lives.

Such coinvestigation appears to hold promise at two levels. One is at the level of cognitive strategy acquisition. As we indicated in an earlier section, coinvestigation is most applicable for cognitive strategies that cannot reliably be acquired through observation, practice, and the learning of explicit rules. Strategies involved in the construction of personal knowledge are preeminently of this kind—remote from observation, inaccessible to assigned practice, and difficult to formalize under rules.

The other level is the level of direction and purpose. Students cannot be expected to take a self-directive role in their cognitive development unless they themselves, and not just the teacher, have a sense of where development is heading—where the growing edge of their competence is and what possibilities lie ahead. Studying theories of developmental psychology is not likely to give

students such knowledge in a usable form. Active investigation of their own cognitive strategies could do so, however—especially if it is done in collaboration with an adult who can help them recognize and reflect upon what is happening and help them experiment with possible next stages in development.

## ACKNOWLEDGMENTS

This chapter is based primarily on work made possible by a grant from the Social Sciences and Humanities Research Council of Canada. Additional support came from the Alfred P. Sloan Foundation and from the Ontario Institute for Studies in Education. We wish to thank Robbie Case for helpful suggestions, and the editors of this book for their careful review of a draft of this chapter.

## REFERENCES

Bereiter, C., & Scardamalia, M. From conversation to composition: The role of instruction in a developmental process. In R. Glaser (Ed.), *Advances in instructional psychology* (Vol. 2). Hillsdale, N.J.: Lawrence Erlbaum Associates, 1982.

Bereiter, C., & Scardamalia, M. Cognitive coping strategies and the problem of "inert knowledge." In S. S. Chipman, J. W. Segal, & R. Glaser (Eds.), *Thinking and learning skills: Current research and open questions* (Vol. 2). Hillsdale, N.J.: Lawrence Erlbaum Associates, in press. (a)

Bereiter, C., & Scardamalia, M. Levels of inquiry in writing research. In P. Mosenthal, S. Walmsley, & L. Tamor (Eds.), *Research in writing: Principles and methods*. New York: Longman International, in press. (b)

Bereiter, C., & Scardamalia, M. Schooling and the growth of intentional cognition: Helping children take charge of their own minds. In Z. Lamm (Ed.), *New trends in education*. Tel-Aviv: Yachdev United Publishing Co., in press. (c)

Bereiter, C., Scardamalia, M., & Cattani, C. *Recognition of constraints in children's reading and writing*. Paper presented at the annual meeting of the American Educational Research Association, Los Angeles, April 1981.

Bereiter, C., Scardamalia, M., & Turkish, L. *The child as discourse grammarian*. Paper presented at the annual meeting of the American Educational Research Association, Boston, 1980.

Bird, M. *Reading comprehension strategies: A direct teaching approach*. Unpublished doctoral dissertation, The Ontario Institute for Studies in Education, 1980.

Brown, A. L. Development, schooling, and the acquisition of knowledge about knowledge: Comments on Chapter 7 by Nelson. In R. C. Anderson, R. J. Spiro, & W. E. Montague (Eds.), *Schooling and the acquisition of knowledge*. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1977.

Brown, A. L. Knowing when, where, and how to remember: A problem of metacognition. In R. Glaser (Ed.), *Advances in instructional psychology* (Vol. 1). Hillsdale, N.J.: Lawrence Erlbaum Associates, 1978.

Brown, A. L., & Campione, J. C. Inducing flexible thinking: A problem of access. In M. Friedman, J. P. Das, & N. O'Connor (Eds.), *Intelligence and learning*. New York: Plenum, 1981.

Burtis, P. J., Bereiter, C., Scardamalia, M., & Tetroe, J. The development of planning in writing. In C. G. Wells & B. Kroll (Eds.), *Exploration of children's development in writing*. Chichester, Eng.: John Wiley & Sons, in press.

Butterfield, E. C., Siladi, D., & Belmont, J. M. Validating theories of intelligence. In H. W. Reese & L. P. Lipsitt (Eds.), *Advances in child development and behavior* (Vol. 15). New York: Academic Press, 1980.

Case, R. A developmentally based approach to the problem of instructional design. In S. S. Chipman, J. W. Segal, & R. Glaser (Eds.), *Thinking and learning skills: Current research and open questions* (Vol. 2). Hillsdale, N.J.: Lawrence Erlbaum Associates, in press.

Case, R., Kurland, D. M., & Goldberg, J. Operational efficiency and the growth of short-term memory span. *Journal of Experimental Child Psychology*, 1982, *33*, 386–404.

Cloward, R. D. Studies in tutoring. *Journal of Experimental Education*, 1967, *36*, 14–25.

Ericsson, K. A., & Simon, H. A. Verbal reports as data. *Psychological Review*, 1980, *87*, 215–251.

Flavell, J. H. Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry. *American Psychologist*, 1979, *34*, 906–911.

Flavell, J. H., Speer, J. R., Green, F. L., & August, D. L. The development of comprehension monitoring and knowledge about communication. *Monographs of the Society for Research in Child Development*, 1981, *46*(5, Serial No. 192).

Flavell, J. H., & Wellman, H. M. Metamemory. In R. V. Kail & J. W. Hagen (Eds.), *Perspectives on the development of memory and cognition*. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1977.

Groen, G. J., & Resnick, L. B. Can preschool children invent addition algorithms? *Journal of Educational Psychology*, 1977, *69*, 645–652.

Hayes, J. R., & Flower, L. Identifying the organization of writing processes. In L. W. Gregg & E. R. Steinberg (Eds.), *Cognitive processes in writing*. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1980.

Hayes-Roth, B., & Hayes-Roth, F. A cognitive model of planning. *Cognitive Science*, 1979, *3*, 275–310.

Meichenbaum, D. Cognitive factors in behavior modification: Modifying what clients say to themselves. In C. M. Franks & G. T. Wilson (Eds.), *Annual review of behavior therapy: Theory and practice*. New York: Brunner-Mazel, 1973.

Montessori, M. *The absorbent mind*. New York: Holt, Rinehart, & Winston, 1967.

Neches, R. *Promoting self-discovery of improved strategies*. Paper presented at the annual meeting of the American Educational Research Association, San Francisco, April 1979.

Paris, P., Scardamalia, M., & Bereiter, C. *Synthesis through analysis: Facilitating theme development in children's writing*. Paper presented at American Educational Research Association, New York, March 1982.

Paris, S. G., & Lindauer, B. K. The development of cognitive skills during childhood. In B. Wolman (Ed.), *Handbook of Developmental Psychology*. Englewood Cliffs, N.J.: Prentice–Hall, 1982.

Paris, S. G., & Myers, M. Comprehension monitoring in good and poor readers. *Journal of Reading Behavior*, 1981, *13*, 5–22.

Paris, S. G., Newman, R. S., & McVey, K. A. Learning the functional significance of mnemonic actions: A microgenetic study of strategy acquisition. *Journal of Experimental Child Psychology*, 1982, *34*, 490–509.

Pavarotti, L., & Wright, W. *My own story*. New York: Doubleday & Company, Inc., 1981.

Perfetti, C., & Lesgold, A. Discourse comprehension and sources of individual differences. In M. Just & P. Carpenter (Eds.), *Cognitive processes in comprehension*. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1977.

Rohwer, W. D., Jr. Elaboration and learning in childhood and adolescence. In H. W. Reese (Ed.), *Advances in child development and behavior* (Vol. 8). New York: Academic Press, 1973.

Rosenthal, T. L., & Zimmerman, B. J. *Social learning and cognition*. New York: Academic Press, 1978.

Scardamalia, M., & Bereiter, C. *Development of dialectical processes in composition*. In D. Olson,

N. Torrance, & A. Hildyard (Eds.), *Literacy, language and learning: The nature and consequences of reading and writing*. Cambridge University Press, in press. (a)

Scardamalia, M., & Bereiter, C. The development of evaluative, diagnostic, and remedial capabilities in children's composing. In M. Martlew (Ed.), *The psychology of written language: A developmental approach*. London: John Wiley and Sons, in press. (b)

Scardamalia, M., & Bereiter, C. Development of strategies in text processing. In H. Mandl, N. Stein, & T. Trabasso (Eds.), *Learning and comprehension of texts*. Hillsdale, N.J.: Lawrence Erlbaum Associates, in press. (c)

Scardamalia, M., & Bereiter, C. Fostering the development of self-regulation in children's knowledge processing. In S. S. Chipman, J. W. Segal, & R. Glaser (Eds.), *Thinking and learning skills: Current research and open questions* (Vol. 2). Hillsdale, N.J.: Lawrence Erlbaum Associates, in press. (d)

Scardamalia, M., Bereiter, C., & Fillion, B. *Writing for results: A sourcebook of consequential composing activities*. Toronto: OISE Press, 1981. (Also, La Salle, Ill.: Open Court Publishing Company, 1981.)

Scardamalia, M., Bereiter, C., & Goelman, H. The role of production factors in writing ability. In M. Nystrand (Ed.), *What writers know: The language, process, and structure of written discourse*. New York: Academic Press, 1982.

Siegler, R. S. Developmental sequences within and between concepts. *Monographs of the Society for Research in Child Development*, 1981, *46*(2, Serial No. 189).

Strunk, W., Jr., & White, E. B. *The elements of style*. New York: Macmillan, 1959.

Tetroe, J. *The effects of children's planning behavior on writing problems*. Paper presented at the annual meeting of the American Educational Research Association, Los Angeles, 1981.

Tetroe, J., Bereiter, C., & Scardamalia, M. *How to make a dent in the writing process*. Paper presented at the annual meeting of the American Educational Research Association, Los Angeles, 1981.