Encouraging Mindful Use of Prior Knowledge: Attempting to Construct Explanatory Answers Facilitates Learning

Michael Pressley  
*University of Maryland*

Eileen Wood  
*Wilfrid Laurier University*

Vera E. Woloshyn  
*University of Western Ontario*

Vicki Martin  
*University of Windsor*

Alison King  
*California State University, San Marcos*

Deborah Menke  
*University of Maryland*

Four lines of evidence, proceeding from correlational outcomes to findings from true experiments, are reviewed as preliminary support for the hypothesis that learning is increased when students attempt to construct explanatory answers to questions about to-be-learned content (i.e., answers requiring inferential transformation of questioned material). The lines of evidence are as follows: (a) When students generate explanatory answers to questions as part of learning in a group, better learning occurs for students doing the explaining. (b) Manipulations that increase student generation of explanations to questions during group interaction increase learning. (c) Attempting to predict the content of upcoming text by responding to prequestions (including

Requests for reprints should be sent to Michael Pressley, EDHD-Benjamin Building, University of Maryland, College Park, MD 20742.
explanatory justifications for predicted answers) increases learning of prequestioned content. (d) Attempting to explain the significance of to-be-learned facts increases learning of those facts. Requiring learners to construct explanatory answers about new content probably improves learning because students do not spontaneously attempt to explain to themselves the significance of to-be-learned content. We hypothesize that attempting an explanation induces the learner to relate the new material to prior knowledge. Potential directions for future research are emphasized.

When people process meaningful materials, they often do so superficially. People fail to figure out why relations stated in text are true, although they are capable of doing so (for an analysis of this point, see Schank, 1988). They do not relate new input to similar content encountered in the past, even though they can see relationships between present materials/tasks and previous materials/tasks if prompted (e.g., with a hint; Gick & Holyoak, 1980, 1983; Ross, 1984). Glaring inconsistencies can be overlooked (e.g., Markman, 1977, 1979). As Langer (1989) put it, people often process information mindlessly. An important consequence of such mindlessness is less complete understanding, learning, and memory than would occur if people mindfully analyzed new information with respect to what they already know.

One way to increase students' thinking about potential relationships between new content and prior knowledge is to require them to answer questions about new content. Consistent with this perspective, asking questions improves students' acquisition of textually presented information (Anderson & Biddle, 1975) as well as of material presented in the classroom (Winne, 1979). Unfortunately, learning gains following questioning are often small (e.g., Hamilton, 1985; Redfield & Rousseau, 1981). A number of questioning effects evaporate completely when factors such as total study time are taken into account (Faw & Waller, 1976). This may be because many questioning interventions affect only selective attention or other processes (e.g., rehearsal) that do not require meaningful manipulation and transformation of to-be-learned materials (Andre, 1987). Thus, when responding to such questions, learners fail to "deeply" process material (e.g., Hyde & Jenkins, 1973); they especially fail to reflect on the material mindfully and relate the new content to their prior knowledge.

In contrast, some recent studies have included questioning treatments designed explicitly to promote transformations of and inference making about new content. They do so by encouraging students to generate explanatory answers to questions about the to-be-learned material. These treatments involve students' engaging in the types of explanation activities
that theorists such as Schank (1988) view as critical to real understanding. This review focuses on studies that have isolated the effects of generating such inferential explanations to questions. Four types of evidence are identified that converge to support an old hypothesis (e.g., Rickards & DiVesta, 1974; Rickards & Hatcher, 1977). Attempting to generate elaborative, thoughtful answers to questions accompanying meaningful content (i.e., explanatory answers going well beyond the information as presented) increases the learning of that content. Our hypothesis is that all four types of outcomes occur because construction of explanatory answers requires the learner to relate to-be-learned content pertaining to the questions to prior knowledge possessed by the learner.

CORRELATIONS BETWEEN GENERATING EXPLANATIONS DURING ACADEMIC INTERACTIONS AND ACHIEVEMENT

Educational psychologists have recently analyzed interactions in small groups of children attempting to solve problems (for a review of 19 such studies, see Webb, 1989). Although the problem types varied between studies, ranging from ones involving simple arithmetic operations to computer programming, all students were told to ask for help from their peers before consulting the teacher. They were also informed that it was their responsibility to learn how to do the types of problems covered in group.

Receiving explanations about problems from teachers or fellow students correlated negatively with achievement, when it correlated significantly at all. The more explanations received, the lower the subsequent understanding of problems. Even receiving especially good explanations, often to questions posed by the learners themselves, did not produce increased understanding. How might this pattern of outcomes be explained? One explanation may be that students receiving elaborated answers might be weaker students. Because the number of explanations provided to students varies with the number of questions asked by them, and because weaker students often ask more questions, the lack of positive effects due to provision of elaborations may be an artifact of differences in ability between students who ask questions and those who do not.

In contrast, about two thirds of the correlations between self-generated explanations and achievement were positive and significant. Generating elaborated answers to questions posed by peers stimulates a variety of cognitive processes that might not occur otherwise. Webb (1989) made this case as follows:
In explaining to someone else, the helper must clarify, organize, and possibly reorganize the material (see Bargh & Schul, 1980). [The helper] may discover gaps in his or her own understanding or discrepancies with others' work or previous work [and] may search for new information and subsequently resolve those inconsistencies, thereby learning the material better than before. . . . When an explanation given to a teammate is not successful (the teammate does not understand it or does not use it to solve the problem correctly), the helper is forced to try to formulate the explanation in new or different ways. This may include using different language . . . generating new or different examples, linking examples to the target student's prior knowledge or work completed previously, using alternative symbolic representations of the same material . . . and translating . . . the same material. All of these activities will likely expand and solidify the helper's understanding of the material. (p. 29)

As Webb acknowledged, however, high-quality, student-produced elaborations may not be the cause of achievement, but rather reflect the high ability required for both high achievement and generation of good explanations.

Although the research reviewed by Webb (1989) cannot provide unambiguous cause-and-effect conclusions, the findings she summarized are consistent with outcomes in experimental studies that were able to provide information about causes of differential learning. For instance, peer tutors benefit at least as much as peer tutees, with the effects on tutors mediated by their explaining content to tutees (e.g., Allen, 1976). Similarly, when students work in cooperative pairs (Dansereau, 1988), those who explain learn more than those who listen and check for errors. More directly relevant here, there has been experimental research specifically directed at determining whether attempting to generate explanatory answers causes improved learning. As summarized in the next three sections, it does.

EXPERIMENTS ON RECIPROCAL PEER QUESTIONING

King (1990; in press) was aware of Webb's conclusions. All of the college students in her Experiment 1 heard a lecture on the topic of evaluation. After the lecture, students in both a reciprocal peer-questioning condition and a discussion condition were told to work cooperatively in small groups for 10 min to help one another learn new material. Students in the reciprocal peer-questioning group were taught a complex strategy, designed to increase the number of elaborative answers generated relative to the number that occurs during unstructured discussion. Specifically, students were instructed to generate thought-provoking questions by using particular stems. They generated questions prompting applications (e.g., "How would you use . . . to . . . ?"), examples (e.g., "What is a new example of . . . ?"),
analyses (e.g., "Explain why . . ."), examination of relationships (e.g., "How does . . . affect . . .?"), and evaluations (e.g., "Do you agree or disagree with this statement?") of to-be-learned concepts. Such questions were designed to stimulate thoughtful explanations of issues pertaining to the content being studied.

Consistent with King's assumption, reciprocal peer-questioning students provided more elaborative explanations during study than did students in the simple discussion condition. (For detailed commentary about how typical peer-collaborative academic discussions can fail to include a high percentage of self-generated elaborations, see Resnick, 1989.) Moreover, the reciprocal peer-questioning students outperformed the discussion students on an objective test covering the content of the lecture. Nonetheless, because of other differences between the reciprocal peer-questioning and discussion conditions—most critically, reciprocal peer-questioning students asked more total questions—it was impossible to draw a firm conclusion about the role of explanation generation as a mediator of learning in Experiment 1.

In Experiment 2 (King, 1990), students listened to a lecture and then participated in group discussion. One of the two conditions in Experiment 2 was operationally identical to the reciprocal peer-questioning condition of Experiment 1 (referred to here as the guided reciprocal peer-questioning condition). Students in the second condition, unguided reciprocal peer-questioning, also were trained to generate questions while studying, except that they were not taught to use the set of stems devised in Experiment 1 to promote generation of questions requiring elaborated responses.

Experiment 2 provided some support for the hypothesis that generating elaborated answers to questions promotes learning. First, there was no confounding between condition and the number of questions generated during study, as had been the case in Experiment 1. There were approximately equal numbers of questions generated in both conditions. As expected, students in the structured condition generated more questions that required critical thinking and provided more elaborated answers than did students in the unstructured condition. Most important, comprehension was greater in the structured than in the unstructured condition. King's (1990) results (see also King, in press) supported the conclusion that generating elaborative answers to thought-provoking questions promotes learning.

RESPONDING TO PREQUESTIONS ACCOMPANYING TEXT

Pressley, Tanenbaum, McDaniel, and Wood (1990) noted an important consistency in studies concerned with prequestioning of prose content: The
effects of readers attempting to answer prequestions have not been evaluated systematically, and, in many studies of prequestioning, attempting to answer prequestions was not required. These seemed important oversights, because better learning would be expected if readers responded to prequestions correctly. Constructing a correct response would require meaningful processing of a question (cf. Rickards, 1976; Rickards & Divesta, 1974; Rickards & Hatcher, 1977; Watts & Anderson, 1971), including activation and manipulation of prior knowledge about the topic of the upcoming text. Such activation might also produce greater attention to text information consistent with the correct response constructed during prequestioning (see Anderson & Pearson, 1984).

Moreover, better learning might even be expected if prequestions were answered incorrectly. If prequestions are effective only because exposure to them directs attention to question-relevant text content (Anderson & Biddle, 1975), learning of content related to prequestions should be enhanced regardless of the quality of the responses to the prequestions. In addition, trying to answer the prequestions should increase memory of them and thus increase the likelihood that information related to prequestions would be spotted and differentially processed during reading. Again this should occur regardless of the correctness of prequestion responses. Positive effects after incorrect responses to prequestions might also be predicted by some versions of schema theory (e.g., Graesser & Nakamura, 1982; O'Brien & Myers, 1985; Schank, 1982). According to these positions, information that conflicts with errant schema already possessed by a learner (e.g., incorrect prior knowledge causing an incorrect prequestion response) might be especially noted when it is encountered during reading. If so, it might be remembered better because of deliberate attention to and encoding of it, with it potentially replacing the errant prior knowledge that was inconsistent with it.

Nonetheless, negative effects due to answering prequestions incorrectly are also a possibility. Memory of text might be distorted or reduced by undue attention to, inappropriate inferences consistent with, and intrusions from an irrelevant knowledge base that is activated by attempting prequestions (e.g., Anderson & Pearson, 1984; Brown, Smiley, Day, Townsend, & Lawton, 1977; Pichert & Anderson, 1977). Moreover, incorrect responses to prequestions could produce simple proactive interference with learning correct responses (e.g., Underwood, 1957).

These possibilities motivated Pressley et al. (1990) to evaluate the effects of attempting prequestions about a passage before reading it. All participants in their study read a chapter of university-level text. The three conditions of the experiment varied during the prereading period. Two groups of subjects were presented 23 prequestions, each corresponding to a question of the posttest. Subjects in the prequestioned condition were
required to attempt these 23 prequestions, explaining their answers on the basis of prior knowledge. Students in the prequestion-exposure condition did not answer the prequestions but instead analyzed each prequestion semantically to determine whether it made sense. These prequestion-exposure subjects spent as much time working on this task as the prequestioned subjects spent generating answers for the 23 prequestions. The third group in the study was not exposed to the prequestions at all before reading the passage. After reading the entire text, all subjects responded to short-answer test questions.

All indications from this experiment were that attempting to answer and justify responses to prequestions improved learning of prequestioned content. Correct responding to prequestions improved learning of prequestioned content compared with both no-exposure control and prequestion-exposure subjects. When prequestioned subjects responded incorrectly to prequestions before reading, there was descriptively greater recall on the posttest by prequestioned subjects than by control participants, although the effect was not statistically significant (i.e., approximately a half standard deviation advantage relative to the control condition mean and standard deviation; Hedges & Olkin, 1985).

Recent data generated by Fielding, Anderson, and Pearson (1990) complemented Pressley et al.'s (1990) results. They found that elementary school children's comprehension of narratives was improved when they attempted to predict the content of narratives if the predictions required them to justify their answers. There is good reason to encourage students to generate potential answers to prequestions as well as defenses of those answers.

ELABORATIVE INTERROGATION

Pressley and his colleagues also have explored a method they dubbed elaborative interrogation, because students generate elaborations in response to why questions about to-be-learned facts. Study of the effects of elaborative interrogation on prose learning followed a series of experiments (Pressley, McDaniel, Turnure, Wood, & Ahmad, 1987; Pressley, Symons, McDaniel, Snyder, & Turnure, 1988) in which university students had been presented sets of isolated factual statements to learn. For instance, Canadian university students studied pieces of information about each of the Canadian provinces (e.g., "British Columbia is the province with the highest proportion of its population in unions" and "The first schools for deaf children were established in Quebec"; Pressley et al., 1988, Experiment 3). The memory of such facts was greatly improved when students answered why questions about the pieces of information (e.g., "Why would it make
sense that the first educational radio station was in Alberta?") Pressley et al.'s (1988) preferred explanation of this effect was that answering why questions activated prior knowledge related to the to-be-learned facts. Presumably this knowledge would not have been activated by learners without why-question prompting. (This potential explanation is considered further in the General Discussion.)

More recent studies have involved learning of facts embellished in paragraph-length prose. Woloshyn, Willoughby, Wood, and Pressley (1990) presented Canadian university students with one-paragraph descriptions of five Canadian universities. Each paragraph contained six facts about a particular campus. The University of Calgary was described as follows:

The park-like atmosphere at the University of Calgary is partially maintained by the school's policy that no cars be allowed on campus. Some of Canada's best research institutes, like the Arctic Institute of North America, are located on or near the campus. The university also has a wilderness information and communication center on campus. The school has a theatre that is modeled on Stratford. The school's art museum has a very fine collection of ancient coins. Unfortunately, the school offers very few intramural sports.

Students in the elaborative interrogation condition were taught to treat each of the six facts as why questions (e.g., Why are some of the country's best research institutes located on or near this campus?). They answered each of these why questions aloud, experiencing little difficulty doing so. Students in a reading control condition read and studied the paragraphs for the same amount of time that elaborative interrogation participants processed the passages.

The elaborative interrogation instructions greatly facilitated memory of the facts presented in prose. The results were striking for two reasons.

First, the learning gains produced by elaborative interrogation were generally large (Cohen, 1988). For instance, collapsing over two experiments, the recall advantage in the elaborative interrogation condition was 1.07 SDs (relative to the variances in control conditions).

Second, gains occurred regardless of the quality of response to why questions during study. In fact, even when subjects failed to generate answers to why questions, they were still more likely to remember the material than were reading control participants. Woloshyn et al.'s (1990) interpretation of this effect was that a network of information related to each to-be-learned fact was activated, even when learners could not retrieve enough information from long-term memory to construct a coherent answers to why-questions.

Wood, Pressley, and Winne (1990) demonstrated that elaborative inter-
rogation can benefit younger students (i.e., in Grades 4–8). Their participants were presented paragraphs, each containing six pieces of information about an animal, as in the following example:

The Western Spotted Skunk lives in a hole in the ground. The skunk's hole is usually found on a sandy piece of farmland near crops. Often the skunk lives alone, but families of skunks sometimes stay together. The skunk mostly eats corn. It sleeps just about any time except between three o'clock in the morning and sunrise. The biggest danger to this skunk is the great horned owl.

Students in the elaborative interrogation condition responded to each factual statement in the passages as a why question (e.g., “Why does the skunk live alone?” and “Why do families of skunks sometimes stay together?”). Reading control participants read the text for same amount of entire time as required for reading and question answering in the elaborative interrogation condition. The criterion task was to provide the name of the animal associated with each fact when the fact was provided on a test (e.g., “which animal lives in a hole in the ground?” Answer: “Western Spotted Skunk” or “Skunk”). Elaborative interrogation subjects answered 59% of these questions correctly, compared with 49% in the reading control condition, a 0.85 SD difference. Unlike the adults, however, producing an answer at study was associated with much better recall than not producing an answer. In addition, answers to why questions that were objectively correct (i.e., ones corresponding to answers that biologists provided) were associated with striking memory advantages.

In summary, elaborative interrogation is a powerful method for adults to apply to the learning of facts. Even though the effects on children's learning are not as striking or pervasive (more about this in the general discussion), some gains are obtained beginning in the middle-grade-school years.

GENERAL DISCUSSION

Why Study the Effects of Learner-Generated Explanations?

The main hypothesis considered here, that attempting to generate elaborated answers to questions about new content promotes acquisition of the material, was supported. Moreover, most of that support was produced in true experiments with demanding control conditions (e.g., total study time was carefully controlled in this work).

Generating explanatory answers did not always produce large learning gains, however. For instance, Webb (1989) reported a wide range of
correlations between explanations and achievement (−.30 to .53, although the −.30 was the only negative correlation) with a modest mean correlation (mean \( r = .26 \)). The effects produced by answer generation were less than 1 SD in size (small- to moderate-sized effects; Cohen, 1988) both in King's (1989, 1990, in press) work and in Pressley et al.'s (1990) study. More positively, with adults, elaborative interrogation has generally produced effects larger than 1 SD, and sometimes effects have been huge (greater than 2 SDs).

A cynical way to view these outcomes would be as only specific instances of student activity facilitating learning and thus drawing the conclusion that this work is not novel or interesting. We do not accept this cynical perspective, however, if for no other reason than the situations studied in this research mirror real-world learning opportunities. For instance, academic discussions such as those studied by Webb (1989) and King (1989, 1990, in press) can occur at all levels of education. Fact acquisition from text is also common. In addition, all research summarized here included control conditions that involved active learning. Thus, student activity per se could not account for the results reviewed in this article. Attempting to answer and explain produced the positive effects. Finally, the cynic's view can be rejected because work on student explanations has the potential to inform a number of important theoretical issues about memory and memorization. Some of the specific issues that might be clarified by additional research on explanation-mediated learning are covered in the remainder of this discussion.

Why Are There Failures to Elaborate To-Be-Learned Factual Content Automatically?

What happens when people are presented factual content to learn? Sometimes they are extremely active in processing such material, elaborating content by relating it to relevant prior knowledge (for reviews of research, see Graesser & Bower, 1990). Such automatic elaborative activity is less likely, however, when learners are processing expository materials rather than narratives (e.g., Britton, Van Dusen, Glynn, & Hemphill, 1990; Britton, Van Dusen, Gulgöz, & Glynn, 1989; Christopoulou, Rohwer, & Thomas, 1987; Graesser, 1981; Spires, Donley, & Penrose, 1990). Most of the data reported here reinforce the conclusion that unprompted elaboration of to-be-learned expository content is not as complete as it might be. If learners mindfully analyzed new content with respect to knowledge related to that material, additional prompts to elaborate, such as why questions, would not be effective.

One possible explanation for less than complete elaboration of expository materials in the absence of prompting has been suggested by Garnham
(1982). He proposed an omission theory of encoding, arguing that any inference that could be made when materials were presented typically would not be made during study. The reader presumes that any inference that can be made to text can also be made from a memory of text, so the need to make the inference at study is not obvious. According to this point of view, readers do not realize that sometimes, such as when mutually interfering facts are learned (e.g., in the elaborative interrogation studies), inferential elaborations can reduce interference by reducing the apparent arbitrariness of the relationships specified in the facts. When that is the case, the text may only be remembered if elaborations are generated at study.

Britton et al. (1990) offered some other reasons why extensive elaborations may not be made with expositions. Elaborations require time and effort, and they interrupt the flow of text, which sometimes seriously disrupt processing. Britton et al. added, “the call for inferences does not appear to add any interest value to . . . instructional texts. . . . Instead, the call for inferences in an expository instructional text can be regarded as an obstacle placed in the path of the reader” (p. 68).

Additional research on question answering may help to illuminate whether either of these mechanisms accounts for failures to elaborate expository content completely. For the time being, however, the descriptive conclusion that adults do not spontaneously elaborate exposition as completely as they could is well supported.

What Role Did Prior Knowledge Play in Mediating The Explanatory Answer Generation Effects Reported Here?

Generating answers to thought-provoking questions may promote learning by activating relevant prior knowledge. Alternatively, it could be that such gains reflect the "generation effect," that materials are acquired better when learners must generate information in response to them (e.g., Slamecka & Graf, 1978). Generating explanatory answers might also be effective by inducing conscious processing of materials, producing arousal, requiring cognitive effort, or promoting deep encodings (Jacoby, 1978; Slamecka & Graf, 1978; Tyler, Hertel, McCallum, & Ellis, 1979).

Research is beginning to appear that challenges most, if not all, of the alternatives to activation and use of prior knowledge as the mediator of the large elaborative interrogation effects obtained in familiar domains. For instance, Martin and Pressley (1991) asked Canadian adults to answer why questions about facts pertaining to Canadian provinces. The directions for answering the why questions varied among four questioning conditions in the study. The subjects answered by searching for and referring only to information about either the province in question or other provinces. In
addition, subjects were asked to specify why the factual relationship was either expected or unexpected. Thus, the questioning conditions could be conceived as a $2 \times 2$ design. There was a fifth control condition.

The four why-question conditions varied systematically with respect to how much subjects searched for information that supported versus interfered with to-be-learned facts. Consider the two most extreme questioning conditions. Subjects asked to indicate why a fact was expected by referring only to the province in question were assumed to be engaging in an elaborative search that was highly supportive of memory for the new fact; they were directed to activate information in long-term memory consistent with the fact as stated. (Notably, the processing in this condition was most similar to processing in elaborative interrogation conditions in the studies reviewed earlier.) In contrast, subjects asked to explain why facts were unexpected in terms of information about other provinces presumably searched information that was much less related to the stated fact.

The results generally were as anticipated from the perspective of the prior knowledge activation/use hypothesis. Clear facilitation was obtained in the expected/refer-to-the-province-in-question condition relative to the control condition. No facilitation occurred in the unexpected/other-province condition relative to this control group. Performances in the other two questioning conditions were intermediate, as was expected because they were intermediate in the extent to which they prompted attention to relevant prior knowledge. In short, how much answering why questions facilitated learning varied with how much the questions stimulated activation of prior knowledge consistent with the new to-be-learned facts. Arousal, effort, and other general factors should have occurred in all questioning conditions and thus could not have accounted for differences in performances between the why-question conditions.

Are There Constraints on Who Might Benefit From Generating Answers?

All of the participants in the studies discussed until this point were 7 years of age or older. When younger children have been asked to answer questions requiring elaborative answers, learning gains have not been striking. For instance, Miller and Pressley (1989) obtained impaired learning in some instances when 4- to 6-year-old children answered why questions about to-be-learned facts. In particular, in some cases in that study, why questions led children to pay attention to information that was largely irrelevant to the important factual content that was to be acquired, even though the questions were designed to point children to supportive prior knowledge. Yedlicka, Wood, Miller, and Pressley (1990) have continued this line of research but have yet to produce striking elaborative
interrogation benefits with children 4-6 years of age. When these results are combined with the Wood et al. (1990) study discussed earlier and then compared with the amount of facilitation observed in adults, there is reason to hypothesize that the potency of elaborative interrogation instructions may increase from early childhood to adulthood. Determining mechanisms that might mediate such a developmental progression could be an important direction for future research. One possibility is that it is due to more extensive or accessible prior knowledge in adults compared with children.

In addition, for some types of children, prior knowledge activation frequently induces activation of prior knowledge only remotely associated with to-be-learned content. Williams (1989) provided evidence that when learning disabled children activate prior knowledge, a stream of bizarre and remote associations can result rather than relevant prior knowledge that would render new content more sensible and memorable. Learner-generated explanations filled with irrelevant information would not be expected to mediate learning.

In summary, the range of populations studied in the investigations reported here is limited. Younger and weaker learners should be studied before use of the procedures covered here is encouraged in the early grade school years or with special populations.

Are There Other Learning Tasks That Should Be Studied for Potential Explanation Effects on Learning?

Some exposition that is really difficult to acquire might prove more learnable if students were required to attempt to explain the materials. Consider the case of scientific principles that are inconsistent with students' preconceptions. Students often fail to understand such content well enough to recognize when and how the newly acquired principles apply to real-world situations (Confrey, 1990). That is, they can learn the correct conception well enough to be able to state it for a test, but continue to apply the incorrect preconception when confronted with real-life applications of the concept. In her dissertation study now in progress, Woloshyn is concerned with whether elaborative interrogation can be adapted so as to assist middle school students in understanding new scientific principles that clash with misconceptions. With one study completed, the tentative conclusion is that elaborative interrogation does facilitate the replacement of misconceptions with newly acquired scientific concepts. Barden is doing similar work with high school students.

The questioning and explaining procedures reviewed herein may be adapted to a wide variety of contents. For instance, consider Chi and Bassock's (e.g., 1989) work on the role of self-explanations in problem
solving. They found a clear association between problem-solving competency and the propensity to generate explanations during problem solving, consistent with self-generated explanation-performance correlations in other problem-solving research (e.g., Davis, Carey, Foxman, & Tarr, 1986; Gagné & Smith, 1962; Wilder & Harvey, 1971). Interrogation procedures are also being developed to promote aspects of comprehension traditionally ignored by educational psychologists. Farnan and Kelley (e.g., 1988) have been studying ways to increase readers' personal reactions to books, particularly critical evaluations and interpretations of what is read. For instance, Farnan and Kelly asked students to tell (a) about a book they read, (b) what the book reminded them of in their own lives, and (c) whether or not they liked the book and why. Similar approaches are being developed for use with other types of literacy content. For instance, Pallante (1989) studied the effects of such questioning on children's processing of poetry. Formal comparisons between the interventions devised by the literary community and those devised by educational psychologists might go a long way toward promoting understanding of literary responses attributable to questioning and answering, as well as the consequences of such literacy behaviors for learning.

Can Facilitation Due to Generation of Questions and Due to Generation of Answers Be Added?

Asking students to generate questions about content facilitates learning of that content, if the questions are ones that would require thoughtful analysis of material to answer (e.g., Frase & Schwartz, 1975; for a review, see Wong, 1985). Of course, much of the time, factual content is presented without accompanying questions. Thus, if students are to answer questions on those occasions, they are going to have to generate them on their own. Can learning gains produced by generation of questions be added to learning gains associated with generation of answers? This issue requires studies that include conditions in which both question and answer generation occurs, question generation alone occurs, and question answering alone occurs. One motivation to conduct such analytical research is that when both question generation and explanatory question answering have been required of university students, there have been impressive improvements in performance over demanding control conditions (for an especially clear example, see King, 1989).

One explanation of these effects may be that learners who generate their own questions very likely activate prior knowledge or experience relevant to their own learning needs. In contrast, textbook- or teacher-provided questions may presuppose knowledge an individual student does not have or does not consider relevant. If, as suggested earlier, prior knowledge plays
an important role in question-answering effects, generating one's own questions should facilitate this process. By constructing questions, students are likely to activate prior knowledge or experience relevant to the task at hand. Attempting to respond to self-generated questions should also stimulate prior knowledge.

CLOSING COMMENTS

It is strange that so much work has been done on questioning in the last 30 years and yet so little research has been done on the effects associated with generating explanatory answers to questions. One likely explanation for the general lack of interest is that early research on generation of elaborated answers produced circumscribed outcomes. Thus, whether answering thought-provoking questions during study stimulated learning in Rickards and DiVesta's (1974) study varied with pace-of-presentation variables. Rickards and Hatcher (1977) reported positive effects with low-ability child readers but not with other children. One possible reason for the less than robust effects in these earlier studies may be that in these experiments answering questions required generating an explanation only to oneself (i.e., quietly generating the explanation while working individually through the materials). Explaining to others, as was required in all of the studies reviewed here, is more demanding. Perhaps the generally consistent effects detected in the main studies summarized here will spark greater interest in explanation answer generation as a mediator of learning than did the more situationally specific effects reported by Rickards and his associates during the 1970s. We emphasize, however, the tremendous debt to Rickards for his initial conceptualizations of the problem.

Research on student construction of elaborated answers has potentially profound implications for education. For instance, classroom discussions can be structured so that there are few or many opportunities for each student to generate answers to questions that are posed: A traditional organization of teacher-directed discussion of social studies content would provide a few opportunities; a small group dialogue focusing on students working through a series of "thought" questions related to a social studies lesson would provide many opportunities (for an analysis, see Stodolsky, 1988). Questioning in class can be structured so that students have sufficient time to construct reflective answers, or questioning can be rapid-fire, with teachers providing answers when students do not respond quickly (for a review and analysis of the consequences of long and short wait times, see Tobin, 1987). The studies summarized in this article apparently provide support for the latter over the former possibility, although no confident conclusion can be drawn until there is substantial experimental research.
documenting the effects of attempting to answer questions in real classrooms with real learners learning real subject matter. There is an authentic opportunity here for classroom and laboratory researchers to unite to understand the potential learning implications of trying to explain to-be-learned material to other people. There is opportunity to understand the learning implications of encouraging students to use their prior knowledge mindfully in order to understand new material as fully as they might.

REFERENCES


Faw, H. D., & Waller, T. G. (1976). Mathemagenic behaviors and efficiency in learning from