DISCOURSE PROCESSING
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ACTIVATION AND RESTRUCTURING OF PRIOR KNOWLEDGE AND THEIR EFFECTS ON TEXT PROCESSING

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In two experiments effects of a group problem-solving procedure were assessed.
In Experiment 1 small groups of subjects were presented with a problem they had to discuss. Compared with a control condition the experimental subjects showed superior reproduction and transfer of information relevant to the problem. These effects were attributed to the activating and restructuring properties of the problem-solving procedure.
In Experiment 2 effects of activation and restructuring of prior knowledge on subsequent text processing were examined. A general facilitative effect was found. This result cannot be explained in terms of selective attention induced by prior problem analysis.

INTRODUCTION

Learning by discovery has been considered a useful addition and perhaps even an alternative to existing educational procedures for some time. Jerome Bruner for instance, the first who applied this method on a somewhat broader scale, was of the opinion that discovery learning more than conventional education increases students' intellectual capacities. The method was said to promote the learning of meaningful information, which in turn would have positive effects on long-term retention and transfer. It was also thought to stimulate a student's intrinsic motivation (Bruner, 1961). Bruner's ideas have given impetus to a lot of empirical research, but the yield has not been very significant (Shulman and Keislar, 1966). Learning by discovery does not seem capable of producing the predicted *extra* learning results.

One may wonder why this should be so. After all, the learners in the situations described by Bruner are cognitively active to a high degree and this condition is generally recognized as favoring the learning process. According to Mayer (1975) the disappointing outcome is probably accounted for by the fact that discovery learning only leads to activation of *existing* knowledge. If no confrontation with new knowledge takes place, learning does not occur (Mayer, 1975, p. 539). Mayer derives this hypothesis from his own assimilation theory, which states that new information is absorbed only if three conditions are fulfilled:
1. a certain amount of prior knowledge about the subject to be studied should be present. This is referred to by Mayer as the *assimilative set*: the body of knowledge into which the information newly to be acquired

should be assimilated;
2. the assimilative set should be actually *activated* by the education;
3. during the learning process, knowledge should *interact with new information* to allow development of new knowledge structures (Mayer, 1975; 1979a; 1979b).
As a rule, the third condition is not satisfied by discovery learning. While working on a problem, the student is expected to produce the required additional information *himself*. It does not seem reasonable however to assume that he is able to do so without external assistance.

But what would happen if we let students work on a problem first (as is usual for discovery learning) and *subsequently* confront them with new information relevant to the problem? By modifying the discovery learning approach in this direction all three conditions for learning set by Mayer would be fulfilled in principle. In fact, experience with such a modification is being obtained for a few years, notably in medical education (Neufeld and Barrows, 1974; Schmidt and Bouhuijs, 1980; Neame, 1981). A small group of students under the guidance of a tutor is offered a problem description. The problem usually includes a number of phenomena or events which can be observed in reality. Students are asked to *explain* these phenomena in terms of underlying processes, principles or mechanisms (Schmidt, 1979). They do so by utilizing prior knowledge to formulate hypotheses regarding the process or principle that might underlie the phenomena outlined. They are trying, as it were, to give a tentative description of this process. Subsequently, they collect or receive new information relevant to the problem, by which any ambiguities uncovered during the initial analysis of the problem can be clarified. This variant to learning by discovery is called problem-based learning (Barrows and Tamblyn, 1980).
To be able to make predictions about possible effects of problem analysis on the acquisition of additional information, we refer to schema theory, a much used description of human information processing (Bartlett, 1932; Ausubel, 1968; Minsky, 1975; Rumelhart and Ortony, 1977). This theory states that in the encoding of new information existing knowledge schemata are activated that regulate the process of comprehension (Dooling and Lachman, 1971; Bransford and Johnson, 1972; Anderson and Pichert, 1978). A decisive role in understanding new information is probably played by *inferences* generated by an activated schema (Schank and Abelson, 1977). Inferences may be regarded as hypotheses about information still to be stored that are tested against such information. The outcome of these tests decides on a possible change of existing schemata, which are then said to *accomodate* to the new information (Anderson, 1977). From this perspective learning can be considered a process of differentiation and reconstruction of existing cognitive structures.

Now, if we try with the aid of these notions to describe the cognitive processes taking place in students engaged in problem analysis, the following suppositions might be made. Thinking about the presented problem and discussing it with others activates existing schemata more or less relevant to that problem. These schemata may derive from factual knowledge of the underlying principle or process, from knowledge of analogous processes, or from general world knowledge. The schemata will produce inferences with the aid of which students will try to develop their own cognitive representation of the processes that may be considered responsible for the phenomena contained in the problem description. If the problem cannot be satisfactorily solved with the help of knowledge that students already

have available prior to the discussion, the cognitive representation of the processes underlying the problem will take the form of a *new*, more differentiated construction of the prior knowledge of each contributing individual. The tutor stimulates this process of activation and restructuring of prior knowledge by inducing students to explicate their inferences. He will do so by means of Socratic questioning (Collins, 1977).
In summary we may say that analysis of a problem leads to activation and 'recontextualization' of prior knowledge (Anderson, 1977) and, as a result of the production of inferences, to its restructuring. The availability of more differentiated schemata resulting from the problem analysis should in turn facilitate the processing of new information relevant to the problem.

In two experiments we have investigated a number of the hypotheses expressed here. The first was conducted to find out to what extent problem analysis leads to activation and restructuring of people's prior knowledge with respect to the problem and its underlying process. In the second experiment we examined the effect of problem analysis on the processing of new information. In each experiment we investigated effects on two dimensions customary in this kind of research, the degree to which subjects are capable of *reproducing* problem-relevant knowledge and the degree to which they are able to use this knowledge in new situations: the degree of *transfer* of knowledge.

EXPERIMENT 1

In Experiment 1 the effect of problem analysis on existing cognitive structures was investigated. The question to be answered was whether analysis of a problem according to the method described in the introduction leads to activation and restructuring of schemata.

Method

Subjects.
39 students (8 males, 31 females) of an institute for higher education participated in the experiment. All subjects had previously attended the same type of secondary education (in Dutch: HAVO), with their final examination including biology. They were paid for participation.

Materials.
The materials included a problem description, two multiple-choice tests, and a questionnaire. The *problem* was described as follows:

> A red blood cell (a red blood corpuscle) is transferred to pure water under a microscope. The blood cell swells rapidly and eventually bursts. Another red blood cell is added to an aqueous salt solution and is observed to shrink.
> How can these phenomena be explained?

Subjects were to account for the described phenomena in terms of an underlying process, mechanism, or principle. The problem refers to osmosis. This had been selected because inspection of four biology text books much in use at HAVO schools had shown that this subject was treated in a more or less identical fashion. Homogeneity of the subjects with respect to prior knowledge of biology of course reduces chance variation in the results of the experiment.
Dependent variables consisted of two tests: a reproduction and a transfer test. In the construction of the test items use was made of a text about osmosis and related subjects such as diffusion, turgor, and plasmolysis.

This text was specifically written for Experiment 2. (Further information is given in the description of Experiment 2).
The *reproduction test* was made up of 33 items for a major part written in agreement with recommendations made by Anderson (1972) and Bormuth (1970). This means that the items resulted from paraphrase and transformation of various passages of the text about osmosis. Except for two, all items were of the true/false type, the two exceptions containing three options for answering.
The *transfer test* consisted of 37 items that were supposed to measure the extent to which subjects were able to apply knowledge about osmosis. Most items had the form of small exercises which could be carried out with the aid of information supplied by the text. However, inferences from the text, i.e., assumptions not included in the text but ensuing therefrom, also formed part of the transfer test. The transfer test consisted of 16 true/false items and 21 items with three answering alternatives. To all test items a question mark category was added, so that subjects could indicate that they did not know the correct answer.
The *questionnaire* concerned such biographic data as age, sex, and final examination mark for biology.

Procedure.
Subjects were randomly assigned to one of two conditions. The experimental group consisted of 20 subjects, the control group of 19. Following this randomizing procedure we examined to what degree the groups were comparable in prior knowledge of biology (expressed by the final examination grade). The mean for biology was equal to 6.30 in the experimental group (standard deviation .73) and equal to 6.47 in the control group (standard deviation .69). These small differences did not necessitate subsequent matching.
The experimental group was then randomly divided into three smaller groups (N = 7, 7 and 6). The analysis of the blood cell problem took place in these groups. A female tutor experienced in the use of the method and conversant with the osmosis process was assigned to each of these groups. Tutor and subjects had never met before. The tutor proceeded as follows: she explained the various steps of problem analysis by means of an example and had written the following text on a blackbord: Problem analysis: 1. Reflection. 2. Problem definition. 3. Production of explanations. 4. Elaboration. Subjects engaged actively with the explanation of the method. Before the blood cell problem was presented, the tutor mentioned that problem analysis was not to take more than 15 minutes. The problem description was issued and the group given 1 minute for reading and reflection. Next, the discussion was started, with the tutor acting as discussion leader. She had been explicitly instructed not to reveal any information about the problem and to take care that her summaries also did not implicitly contain information from which subjects might derive insights into the nature of the problem at hand. The discussion was recorded on tape for subsequent verification of the tutor's and her group's compliance with the approach agreed upon. It appeared that all tutors had accurately followed their instructions. The groups needed less than 10 minutes for analysis. On completion of the problem analysis both the experimental group and the control group (which had not been presented with a problem) filled out the questionnaire and answered the multiple-choice tests. Each group was told that the tests were not examinations and that nothing was to be gained by good or poor results. Participants were urged not to guess at the correct answer but in case of doubt to indicate the question mark. The answering of the items was anonymous. Reproduction and transfer scores were calculated by counting the number of correct answers.

Results and discussion

Items that proved to be too easy were removed from the analysis. As a criterion a p-value ⩾.90 was used. It proved necessary to remove 10 items from the reproduction test and 5 from the transfer test. The alpha reliability coefficient for the resulting 23-item reproduction test was equal to .73 and for the 32-item transfer test to .69. These reliabilities compare with those generally obtained in examinations (Wijnen, 1971). The two instruments are considered different on a priori grounds. They were each supposed to measure a different aspect of the subjects' knowledge. Their product-moment correlation was equal to .41. Consequently they have about 16% of variance in common. This means that they each measure the same characteristic to a small degree and a different characteristic to a larger degree. The results of the reproduction test are summarized in Table 1 and those for the transfer test are summarized in Table 2. The results on both tests were subjected to a one-way analysis of variance.

Table 1: Means and standard deviations of reproduction scores for Experiment 1

	M	SD	N
Experimental group	10.90	4.17	20
Control group	8.63	3.00	19
Total	9.79	3.65	39

Table 2: Means and standard deviations of transfer scores for Experiment 1

	M	SD	N
Experimental group	16.55	5.08	20
Control group	13.26	4.40	19
Total	14.95	4.84	39

The analyses of variance show that the actual difference found between the experimental and control conditions are statistically significant at the 10% level. This applies to both reproduction, $F(1,37)=3.77$, $p<.06$, and transfer, $F(1,37)=4.96$, $p<.04$. These results support the theory advanced in the introduction with respect to cognitive effects of problem analysis. It seems that written problems indeed activate existing schemata and that the problem-connected inferences based on these schemata lead to their restructuring. Apparently, the restructured schemata enable subjects in the experimental condition to give better answers to the items of the tests, as compared with the control subjects.

The chosen experimental design does not allow us to separate the effects of activation from those of restructuring of schemata. For in the control group activation of prior knowledge also takes place, notably at the moment subjects in that condition answer the tests. Of course, reading the test items activates prior knowledge as well. Whether the combination of problem and test items activates prior knowledge to the same degree as answering the test items only - and whether the established effects should solely be ascribed to restructuring - remains unclear for the time being.

EXPERIMENT 2

What happens if you ask students who have just tackled the blood-cell problem to study a text about osmosis? What will be the effect of recontextualized and restructured prior knowledge on the processing of text relevant to the problem?
According to the position defended here, problem analysis functions as a bridge between prior knowledge and knowledge still to be acquired. Elaboration of prior knowledge by means of discussion of a problem causes existing cognitive structures to change in the direction of further differentiation and restructuring. Compared with the situation that exists before problem analysis the subjects' schemata will contain concepts that are clearer and have more and closer mutual relationships. In this way it provides a better ideational scaffolding for new information contained in a problem-relevant text (Anderson, et al., 1978). Information from the text will be processed more easily and, consequently, faster. In terms of the second experiment this means that given a standard amount of study time, persons who have first worked on a problem will process a problem-relevant text deeper than others who have only processed the text (Craik and Lockhart, 1972).

If this is the sole effect to be expected from problem analysis, one might just simply extend study time for subjects' text processing (Peeck, 1970) instead of presenting them with a problem-plus-text. However, subjects who have analyzed a problem beforehand will not only process new information faster but also *in a different way*. As a result of the structural changes to which existing schemata have been subjected new information will be comprehended in another, more differentiated manner. This subtler interpretation of the subject-matter will lead to a deeper understanding and consequently to improved application of knowledge in transfer tasks. In other words: schema theory predicts better retention as well as greater transfer. Mayer (1974, 1975) slightly modifies this prediction. He states that different educational procedures often do not lead to an *increase* (or decrease) in learning, but to learning results that are *structurally different*. For instance, education may emphasize the internal structure of information to be acquired, or it may stress relationships with other, already available, knowledge. In the former case, according to Mayer, a cognitive structure develops whose constituent concepts are strongly linked with each other but have few relationships with knowledge elements beyond the domain studied. Mayer refers to this as the 'internal connectedness' of that cognitive structure. In the latter case a cognitive structure develops which has strong connections with knowledge elements outside the specific domain ('external connectedness'). He predicts that educational procedures stressing the internal connections between new concepts lead to improved reproduction of such concepts,and that educational procedures emphasizing relationships between new concepts and other already available knowledge lead to better transfer but poorer reproduction. Research conducted by Mayer and Greeno (1972) demonstrated that these 'treatment post-test' interactions do occur. They gave instruction to subjects on binomial probability by means of two procedures. In one of these the relations between the variables of the binomial formula were emphasized and subjects learned to calculate by using the formula. In the other procedure they tried to establish connections between the variables of the formula on the one hand, and the prior knowledge and experience of subjects with chance, trial, and outcome on the other. The results did not yield an overall difference between procedures on a post test, but did show qualitative differences in the answering of the items. As predicted, the 'internal connectedness' group proved superior in answering items about the relations between variables of the formula, which means that they were better in reproduction tasks. The 'external connectedness' group proved more apt in recognizing unsolvable problems and in solving problems whose variables were concealed in a story. This group, therefore, excelled in items involving transfer. It looks as if emphasis on external relationships of concepts to be learned (the relationship between concepts and learners' prior knowledge) is at the expense of the internal connectedness of concepts to be learned (the mutual relationship between the concepts). Assuming that the reproduction test applied in the present experiment aims exclusively at concepts from the text proper and at their mutual relationships, one would have to predict on the basis of Mayer's considerations that the control group (text-only) will perform better on the reproduction test, whereas the experimental group (problem-plus-text: emphasizing relationships with prior knowledge) will demonstrate a better performance on the transfer test.

The predictions expressed above have all been derived from schema-theoretical notions with respect to how a text is processed. However, there is also another theory about text processing that may be relevant within the scope of this research. This theory is *selective attention theory* (Rothkopf, 1970; Duchastel, 1979; Glynn and Di Vesta, 1979; Reynolds et al., 1979). This theory simply postulates that whatever people learn from a text is a function of the amount of attention paid to various test passages. The amount of attention paid to various passages is in turn a function of the *objectives* of the persons processing the text. Typical for this approach is the following experiment: Two groups of subjects study the same text. One group has been previously given a list of learning objectives or questions relating to the text. Measurement of what has been processed then shows that subjects who have studied the text guided by learning objectives recall goal-relevant information better than the control group. This is achieved however *at the expense* of the storage of information not directly related to the learning objectives.

In an investigation into eye-movements during reading, Rothkopf and Billington (1979) discovered that subjects fixated twice as much on sentences relevant to a learning objective than on sentences which are not. From this they drew the conclusion that what people learn is determined by the amount of selective attention - expressed in amount of inspection time - paid to the text passages to be learned.
The materials used in our experiment were constructed in such a manner that a selective-attention explanation of possible effects could also be tested. We started from the assumption that the blood cell problem (which was worked on by the subjects of our experiment) might play the same role as the learning objectives in the selective-attention experiments. This means that working on problems would induce subjects to pay more attention to problem-relevant passages of the text at the expense of those passages that are less meaningful in the light of the problem. The text about osmosis was edited to include information of lesser relevance to the blood-cell problem. The selective attention theory predicts that subjects of the experimental group (problem-plus-text) will pay greater attention to problem-relevant text passages compared with the control group (text-only), but also that such attention will reduce the attention paid to less

relevant parts of the text. Given an equal amount of study time for both groups, the experimental group will perform better on items concerned with topics relevant to the problem, whereas the control group will do better with non-relevant items. Hence, no overall difference between the two groups is going to be observed in either test. The differential predictions discussed above are summarized in Table 3. The plus-sign means the problem analysis group will perform better on this test (or part of the test) than the control group. A minus-sign means that the control group performance will be better.

Table 3: Differential predictions about the influence of problem analysis on text processing

		reproduction	transfer
Schema theory (Rumelhart and Ortony, 1977)		+	+
Mayer and Greeno's (1972) specification		-	+
Selective attention theory (Rothkopf and Billington, 1979)	items concerned with text relevant to problem	+	+
	items concerned with text not relevant to problem	-	-

Methods

Subjects.
48 students (42 females, 6 males) of an institute for higher education participated in the experiment. All subjects had attended the same type of secondary education (in Dutch: HAVO), with their final examinations including biology. They were paid for participating.

Materials.
The materials used in Experiment 2 were identical to those of Experiment 1. In addition, however, a written text was used.
The 2,220-word *text* was entitled 'Osmosis and Diffusion'. It had been designed to adapt as well as possible to subjects' prior knowledge. The description of the osmosis process was more detailed and precise than is customary for HAVO schools. The text dealt with the following topics: diffusion, diffusion rate, (semi-)permeability of cell membrane, osmosis, osmotic pressure, osmotic value, plant cell structure, turgor, and plasmolysis. Not all of these were directly relevant to the problem. In order to be able to test selective attention theory the two multiple-choice tests were subdivided by two independent judges, including the investigator, into items of immediate importance to the problem and those of lesser relevance. Agreement between judges was 76%. The items about which consensus had not been reached were classified in one of the two categories by mutual agreement. (Removal from the analysis would have left too few items.)

Procedure.
The procedure was largely identical to that of Experiment 1. In the experimental condition 23 subjects were tested and in the control condition 25. Following randomization it was established to what extent the two groups were comparable in prior knowledge of biology (expressed by the final examination grade). The average grade for biology in the control group was 6.36 (standard deviation .81) and 6.39 in the experimental group (standard deviation .94). The experimental group was subdivided into three smaller groups (N=8, 8 and 7). Each of them was randomly assigned an experienced female tutor. The tutor and her group proceeded in the way described for the first experiment. All groups needed less than 10 minutes for analysis. After that the experimental group answered the questionnaire. It was next given the text and instructed to study this. The control group answered the questionnaire and studied the text. Each group was allowed 15 minutes for study.
Finally, subjects took the reproduction and the transfer tests.

Results and discussion

Items having a p-value equal to or larger than .90 were removed from the analyses as being too easy.
The results for reproduction are given in Table 4 and those for transfer in Table 5.

Table 4: Means and standard deviations of reproduction scores for Experiment 2

	M	SD	N
Experimental group	16.17	2.46	23
Control group	14.48	2.63	25
Total	15.29	2.55	48

Table 5: Means and standard deviations of transfer scores for Experiment 2

	M	SD	N
Experimental group	20.04	3.01	23
Control group	17.56	3.45	25
Total	18.75	3.25	48

One-way analyses of variance on these results yield the following picture. Reproduction: $F(1,46)=5.26$, $p<.03$. Transfer: $F(1,46)=7.01$, $p<.02$. These results support the assertion expressed before that analysis of a problem in the way this is prescribed in problem-based learning causes new information to be better understood and remembered. Recontextualization of the assimilative set by means of problem analysis promotes interaction between prior knowledge and new information, which in turn is responsible for the observed gains in the reproduction of such information and its application.

The results do not however support the view of Mayer and Greeno (1972) that intensive interaction between prior knowledge and new information should lead to poorer performance on a test measuring knowledge of the 'autonomous' text (Anderson, 1977), whereas transfer should be promoted. The experimental subjects were also better in reproducing the text. There is a possibility that the reproduction test used in this experiment does not really measure Mayer and Greeno's 'internal connectedness' of the cognitive structure resulting from text processing. Mayer and Greeno do not indicate clearly what exactly they have in mind when using this term, so that our interpretation of the concept - that internal connectedness can be measured by text reproduction - was perhaps not quite correct.

However this may be, schema theory appears to allow correct predictions with regard to the influence activation and restructuring of existing schemata have on the processing of new information.

What about the support for selective attention theory? The answer to this question has not been made superfluous by the previous argumentation because, theoretically, it is possible that problem analysis has a schema-restructuring *as well as* a guiding function. In order to investigate this hypothesis we divided as mentioned the items of the tests into a set directly relevant to the osmotic process and a set of indirect relevance. Items relating to diffusion rate, osmotic value, plant cell structure, turgor, and plasmolysis were regarded as indirectly relevant to the problem. Each of the four subtests resulting from this subdivision has been subjected to an analysis of variance. In addition *all* items of direct relevance from the tests have been combined into a new test and subjected to an analysis of variance. The same was done with *all* indirectly relevant items. The results are given in Tables 6 and 7. These only show mean values and chance probabilities resulting from the analyses.

Table 6: Means and chance probabilities of subtests consisting of items directly relevant to the problem

	reproduction	transfer	total
Experimental group	7.43	11.13	18.57
Control group	6.80	10.16	16.96
Chance probability	<.14	<.13	<.08

Table 7: Means and chance probabilities of subtests consisting of indirectly relevant items

	reproduction	transfer	total
Experimental group	8.74	8.91	17.65
Control group	7.68	7.40	15.08
Chance probability	<.04	<.02	<.01

In the light of selective attention theory these results can hardly be interpreted. Selective attention theory predicted effects favoring the treatment group with respect to subtests consisting of items directly relevant to the problem, whereas the control group would demonstrate better performance on indirectly relevant items. This was not the case. Statistically significant differences were not found in the case of problem-relevant items, whereas the differences established for indirectly relevant items did favoring the treatment group.

If we should nevertheless want to maintain (a combination of schema theory and) selective attention theory in explaining these results, only the following line of thought seems plausible: the way in which the problem analysis group prepares for text study induces this group to pay less attention to problem-relevant information than the control group. Which means that this group has more time available for studying information which is relatively new in the light of the problem. As a result experimental subjects do better on indirectly relevant items and, while study time and type of preparation counterbalance each other on directly relevant information, they do not show poorer performance on directly relevant items. This explanation should be called a boredom-hypothesis, because it suggests that subjects in the treatment condition become bored earlier with the osmosis topic than the control subjects.

GENERAL DISCUSSION

The two experiments discussed here show that analysis of a problem in the way described in this contribution and elsewhere (Schmidt, 1979; Schmidt and Bouhuijs, 1980) causes existing knowledge schemata to be activated and restructured, and that this effect facilitates subsequent processing of a text relevant to that problem. With reference to the introduction of this contribution we may say that Mayer's (1975) diagnosis regarding the effects of discovery learning appears to be correct. Learning by discovery indeed leads to activation of the assimilative set and, as we have demonstrated, to its restructuring. This effect, however, is insufficient to produce the extra learning effects predicted by Bruner, for that calls for actual confrontation with new information.

Of course, the results of the present experiments should to a certain degree be regarded as isolated phenomena. Naturally, it is too early to conclude that elaboration of prior knowledge by means of problem analysis has, in general, a facilitating effect on text processing. We have shown, however, that conditions can be created under which problem analysis effects are demonstrable. Finding out how representative these conditions are and how general the effects certainly requires further research.

Moreover there are some other possible explanations for the results found, interpretations that could not be ruled out by the chosen experimental design. The first is that the established results could be generated by a *Hawthorne effect*. It is possible that the subjects experienced problem analysis as being so new and interesting that it increased their motivation. This alternative explanation might well hold true for Experiment 1. Not so for the second however. The subjects participating in the latter had, some time beforehand, gained an extensive three-months experience with this type of education, so the method was not really new to them. A second alternative derives from motivational descriptions of the learning process (Faw and Waller, 1976; Mayer, 1980). It is not impossible that working on an interesting problem has such a *motivating effect* on subjects that those who have carried out a problem analysis are more interested in a text relevant to that problem than people who have not. There are indications that problem analysis indeed induces a slightly greater motivation. The latter would in turn increase a subject's efforts, so that he/she learns more in less time. However, research on motivation has only rarely established such direct effects on learning. It has been found, though, that motivation influences the *amount of time* students are prepared to spend on material to be studied. We did keep study time constant in our research, so this alternative is not a very likely one.

For that matter, it would be interesting to examine the influence problem analysis has on study time. Would subjects be inclined to spend more time on studying material relevant to a certain problem? Another question concerns the influence of problem analysis on subsequent retrieval of knowledge stored in long-term memory. One could imagine that storage of information, along with the cues provided by problem analysis, facilitates subsequent retrieval (Tulving and Thompson, 1973).
Finally, interactions between subjects' prior knowledge and the structure and difficulty of the text (Mayer, 1980; Kintsch and Van Dijk, 1978), as well as variations in the nature of the problems presented should be studied.

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