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ABSTRACT

Underlying the research reported in this paper is a theoretical framework which defines the self-regulation of learning as the number and kinds of teaching tasks students perform themselves. Three studies are presented on individual differences in regulation-processes emerging from thinking aloud protocols. Protocols of good and weaker performing subjects were compared and related to test scores (impulsivity, intelligence, etc.). Furthermore, students were trained to change their regulation-processes. Training programs consisted of a combination of awareness-training and regulation-training. The subjects were 14, 10 and 6 students from a normal secondary school and two special secondary schools (for children with learning problems), respectively. The results showed some relations between process-differences such as the quality and quantity of testing-processes, the breadth of orientation, on-line regulation and mind-orientation on the one hand and performance on the other hand. There were also influences of task difficulty on the process-data. Training appeared to be effective for only some of the students. Transfer effects failed to show up. (Author/BAE)

INDIVIDUAL DIFFERENCES IN THE SELF-REGULATION OF LEARNING, EMERGING FROM THINKING ALOUD PROTOCOLS

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Individual differences in the self-regulation of learning, emerging from thinking aloud protocols. 1)

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Abstract

After the presentation of the beginnings of a theory on the self-regulation of learning, three studies are reported on individual differences in regulation-processes, emerging from thinking aloud protocols. Protocols of good and weaker performing Ss were compared and related to testscores (impulsivity, intelligence (etc). Furthermore, students were trained to change their regulation-processes. Training programs consisted of a combination of awareness-training and regulation-training. The Ss were 14, 10 and 6 students from a normal secondary school and two special secondary schools (for children with learningproblems), respectively. The results showed some relations between process-differences such as the quality and quantity of testing-processes, the breadth of orientation, on-line regulation and mind-orientation on the one hand and performance on the other hand. There were also influences of task difficulty on the process-data. Training appeared to be effective for some of the students only. Transfer effects failed to show up.

Introduction

Underlying the research to be reported in this paper, is a theoretical framework derived from theories of Boekaerts (1982), Brown (1980), Gagné (1977), Hettema (1979), Klauer (1985), Kuhl (1983) and Lawson (1984). According to this framework the self-regulation of learning is defined as the number and kinds of teaching tasks students perform themselves. Figure 1 presents the various teaching tasks.

The first teaching task (preparing students) has subtasks borrowed from Gagné (1977) and Galpérin (1964). The second task (facilitating learning) is formulated in accordance with proposals of Boekaerts (1982) and Klauer (1985). For the third teaching task we extrapolated from theories of Brown (1980), Hettema (1979), Lawson (1984) and our own research. The fourth task (feedback and judgement) comes from Gagné (1977) and the last one (keeping students motivated and concentrated) stems from research on teacher perceptions of their tasks. We believe that Kuhl's theory om mind- and activity-orientation forms an important tool in conceptualising this last teaching task. Apart from external distractions which draw the students' attention away from the learning task at hand, mind-oriented cognitions form distractors,too.

I Preparing learning	* Orientation on goals, strategies, time, etc. * Planning of learning (time, anticipation of problems, choice of strategies). * Gaining attention. * Promoting self-confidence. * Informing students on goals. * Stimulating recall of prerequisite learning
II Facilitating learning	* aimed at remembering and comprehension. * aimed integration with other information. * aimed at problem solving.
III Regulating learning	* Monitoring. * Testing and questioning. * Revision (re-orientation, diagnosing, reflecting, repairing). * Evaluating learning processes
IV Giving feedback and judging performance	
V Keeping students concentrated and motivated	

Figure 1: A categorization of Teaching Tasks

Teachers should be alert to mind-orientations such as goal-fixation, planning-fixation, failure-fixation and success-fixation. Moreover, they should try to lead students towards activity-orientations in which the goal-state to be reached, the present state, the difference between the goal and the present state and the plan that may be used to change the present state into the goal state each get sufficient attention. One aid they might use to reach these states in students is goal-setting.

Self-regulation, in our opinion, thus pertains to the extent to which one is able to be one's own teacher. This means, according to the scheme of teaching tasks presented: being able to prepare one's own learning, to take the necessary steps to learn (aiming at recall and comprehension, integration and problem solving), to regulate learning, to provide for one's own feedback and judgements and to keep oneself concentrated and motivated. In our conception(see also Hettema, 1979; Lawson, 1984), three levels or perspectives in respect to these tasks should be discerned (see figure 2): (metacognitive) knowledge and conceptions (for instance knowledge of study strategies, knowing when to use certain strategies, or conceptions of self-regulation), executive control or regulation processes (for instance deciding on a plan, attention-maintenance, monitoring, or repair-mechanisms) and transformations or executive skills (for instance paraphrasing, underlining, or reading). In agreement with Lawson (1984) and recent Russian theories (e.g. Zak, 1980) we assume that metacognitive knowledge arises from reflection, (being an executive control process itself) on executive control processes or transformations.

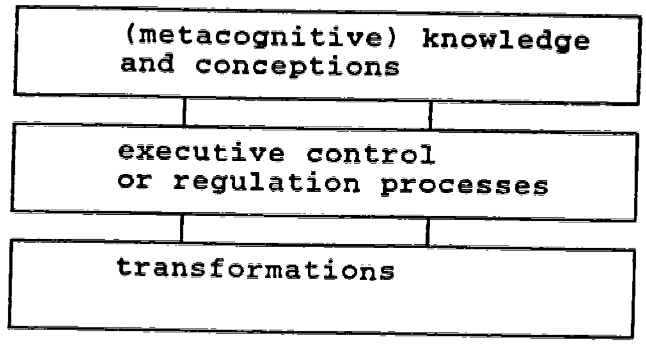

Figure 2: Three perspectives and their interrelations

The most extreme form of selfregulated learning occurs when students perform all of these teaching tasks themselves. Most of the time, however, teachers (or their substitutes, for instance books or computers) take care of at least part of these tasks. In essence, there always seems to be a division of tasks. Extension of the responsibility of students for their own learning may in some cases improve learning. Lodewijks (1981), for instance showed that students learning science concepts in a self-chosen sequence performed better than students learning these concepts in a predetermined sequence. Likewise, Van der Sanden (1986) showed that some students (especially the better ones) performed better on a practical construction task without instructions than with detailed and explicit advice from a teacher.

According to these and other studies improvements of learning might be reached by giving students more opportunities to regulate their own learning. This, however, is problematical in practice . Apart from the students who might profit from these opportunities, there are also students who will perform (still) worse when teacher advice is absent (Lodewijks,1981, Van der Sanden, 1986). A differentiated system with opportunities for self-regulation for the better performing students and sound advice for the weaker students, however, encounters many practical disadvantages and problems. As was discussed by Larsson (1983) paradoxes of teaching should also be taken into account. Some teachers would like to give students more freedom to learn, but do not believe that students are able to handle this freedom. Some students believe that only the teachers should make decisions on learning and seem to hand over all responsibility to the teachers. In our opinion there is only one way out of these and other paradoxes and circularities and that is by training students in self-regulation. One main goal of training programs should then be to convince students that they have a responsibility for their own learning and that they can become able to regulate their learning.

Before such training programs can be developed, however, we need more information about individual differences in self-regulation. As yet we do not know to what extent students have the adequate conceptions and metacognitive knowledge nor do we know how good students are in regulation processes. Good training programs, in our view, should depart from a sound diagnosis of the entering behavior of the students (see also Campione and Armbruster, 1984). Our research strategy thus has been to set up small-scale in depth studies, searching for individual differences in the self-regulation of learning, designing partial, prototypical training programs aiming to influence these individual differences and evaluating the results of training in terms of process- as well as performance differences.

The main research questions were: a) What individual differences in self-regulation occur and which of these relate to performance differences? b) Is there an effect of training on process- and performance-variables? In the studies, reported below, the middle level of Figure 2 (executive control) is accentuated.

In designing training programs we had the following starting-points: a) We based the training on the differences in processes observed during a pretest-session. b) We stressed metacognitive awareness by letting students reflect on their own way of learning and that of other students. c) We emphasized the importance of regulation processes by letting students practice with a set of questions one may pose oneself during learning (e.g. Do I understand this part? What went wrong? Is this in line with the learning goal?) and techniques and skills one may find useful in answering these questions (e.g. paraphrasing, reflection, thinking of new examples, selftesting). d) Finally, non-cognitive variables like concentration, self-motivation, attributions and mind-orientations were also included when possible.

STUDY 1

METHOD

Subjects

The subjects were 14 students from the second year of secondary school. Ages ranged from 13 to 15. There were 7 boys and 7 girls.

Materials

In this study three sets of learning tasks were used, thought to be representative of academic tasks used in lower classes of secondary schools (compare Doyle, 1984). The learning tasks consisted of two parallel texts of 900 words on probability, the one introducing principles, problems and examples of chances with replacement, the other dealing with chances without replacement, two sets of 20 French words and their Dutch translations and two parallel problem solving assignments, in which simple probability principles (introduced in a separate text) had to be applied. In these assignments students were to calculate the number of correct answers to multiple choice tests on the basis of guessing. Following Olshavsky (1976), red dots were put in places in the texts where verbalization was thought crucial. Text-comprehension was tested by means of two multiple-choice-tests of 13 items each, emphasizing understanding instead of retention. Vocabulary-learning was tested by means of a randomized list of the French words that students had to translate in Dutch. The quality of the problem solving outcome was used as indication for the result on the assignments.

For the training program two case-histories were written depicting two totally different ways of learning: a passive way and an active way incorporating several self-diagnostic routines and heuristics. Also a short booklet was written in which a set of questions was described one may ask oneself during learning (e.g. "What do I already know of this subject-matter?", "Why can't I understand this part?" and " which parts are difficult for me?"). Moreover, for each question suggestions were put forward on possible ways to answer these questions. Finally, a set of practice materials (texts, words and problems) were constructed.

Procedure

On a one to one basis students and (two) experimenters proceeded as follows after regular school hours: after a short introduction each student was asked to learn one of the texts, one set of words and to solve one set of problems. They were asked to read and think aloud and to say out loud whatever thoughts occurred to them. They were told that the test items would pertain to comprehension and application and not to reproduction of facts. All the subject's verbalizations were taped and their observable behavior was recorded by the experimenters. Afterwards the tests were completed.

Half of the students participated as a group, in the training program, which occupied three hours in all. In the first session the group discussed different ways of studying, incorporating the two case-histories. During the second and third sessions the students learned the set of questions and the possible ways to answer them and practiced these, receiving feedback from the experimenter.

One or two weeks after the training, the parallel-tasks were learned, again reading and thinking aloud in individual sessions. Finally, the parallel-tests were completed.

Design

The design was a non-randomized pretest-posttest control group design. The training was administered to the subjects that were most in need of it according to the vice-headmaster of the school. The remaining students thus formed a group for comparison only instead of a real control group.

Data-analysis

Verbal protocols and experimenter's observations were combined. As a first step, units of analysis were determined, following a procedure proposed by Wouters and de Jong (1982), which stressed meaningful units rather than sentences. The data were categorized using the categories presented in appendix 1. Definitions and examples of the main categories are presented in appendix 2. Intercoder-agreement was 88 percent.

RESULTS

Table 1 presents the average results on the three tasks for good and weaker students separately, for the main categories only.

Table 1: Mean frequencies of processes in protocols of good and weaker Ss (during pretest-session).

Processes	Text good	Text weak	Vocabulary good	Vocabulary weak	Problem-solving good	Problem-solving weak
Execution	53.4	50.3	18.7	21.7	14.2	8.6*
Orientation	1.4	3.7	2.5	1.3	10.8	4.6*
Monitoring	25.7	25.3	8.6	4.7	9.0	3.5*
Regulation	6.7	8.1	9.1	19.1	12.6	4.6*
Testing	21.6	24.0	27.8	9.3*	3.4	2.6
Diagnosing	6.7	5.7	0.4	0.3	0.6	0.8
Evaluating	0.7	1.6	2.2	2.7	0.8	0.9
Total	116.3	118.7	69.3	49.3	51.4	25.6*

*$p<.05$

There were no differences in frequencies on the main categories between good and weaker Ss in text-processing. However, within the category "testing" a significant difference showed up. Good students tested more frequently on understanding than weaker students (19.0 vs 8.4, $p<.05$)). Weaker students, however tested more often on knowledge (11.1 vs 1.3, n.s.). Thus, not the quantity of testing differentiated good from weaker subjects, but its quality.

In vocabulary learning, however, the quantity of testing was the differentiating variable. Better students tested three times as often as weaker Ss (27.8 vs 9.3 $p< .05$). Differences between good and weaker Ss for the problem-solving task related to the total number of processes registered, and the number of monitoring, regulation and orientation-processes.

The training program had a significant effect ($p<.05$) on the performance of the students on the comprehension test administered after studying the text. The trained group increased its average score with 2 points (out of 13), whereas the comparison group remained on the same level as in the pretest. Performance and processes on the vocabulary-test and the problemsolving-task did neither increase in the training-group, nor in the comparison-group.

The training effect on the comprehension test also showed up in the process-data. In the training group the number of testings on understanding increased from 10.0 to 20.6 ($p<.05$) and the number of testings on knowledge decreased from 9.4 to 3.0 (n.s.) (see Figure 3). In the comparison-group no changes in processes showed up.

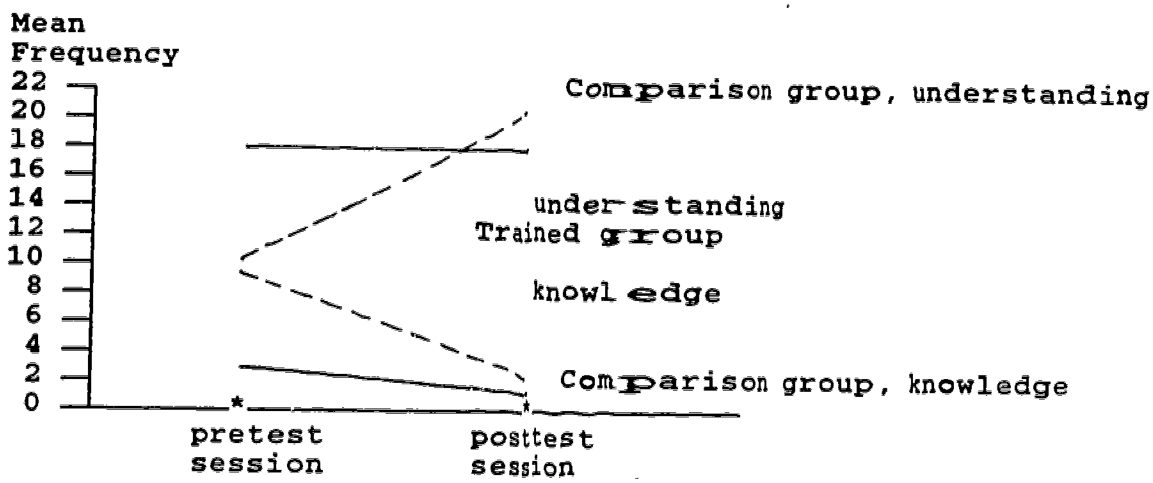

Figure 3: Mean frequencies of testings before and after training

DISCUSSION

This study revealed some interesting relations between performance and individual differences in executive control processes. In text-processing the tuning of self-diagnostics to the learning goal proved to be the most important aspect. In vocabulary learning, however, the amount of selftesting differentiated between good and weaker performing students. In the problem-solving-task both monitoring, regulation and orientation processes showed up more frequently with better Ss. Thus, individual differences in processes correlating to performance were task-dependent. Training proved to be effective for the text-processing only, both for performance- and process-data.

Three cautionary notes should be made. First, because of the small number of Ss participating in this study, replication on a larger scale is necessary. Currently we are doing so in a study with 64 Ss. Second, one should be wary of cause and effect-relations. The quality of executive control processes may cause the effectivity of task-performance. In case of the text-processing data we have reasons to believe that this is what happened. Apart from the correlation between performance and processes, there also was a change in the number of testings on understanding (induced by the training program) coinciding with a change in performance. For the other two tasks, however, the causal relation might also be in the reverse direction. Weak performance (for instance caused by low abilities) might cause the occurrence of particular processes, like noticing negative results, or keeping on planning. Therefore, a distinction between good and bad executive control-processes would be helpful. Kuhl's distinction between mind- and activity-oriented processes might form an improvement (see the next studies). Third, one might also argue that relations between performance and self-regulation processes should not always be expected. Some ways of processing might be preferable to others without leading to better performance, for instance because they are more efficient, or because they keep processing going in difficult circumstances.

The results of the present study also suggest the importance of on-line processes for self-regulation as opposed to processes occurring at the start and at the end of learning (orientation and evaluation). Many training-programs stressed the importance of the latter processes. Nevertheless, in the present investigation these before and after processes a) did not occur very often, b)did not differentiate between good and weak students and c) did not increase in frequency through training. The opposite counts for on-line processes such as selftesting during learning.

The design of the training study was, due to practical arrangements, not optimal. In future studies a real control group consisting of untrained weak students, is to be preferred. Moreover, training should be extended in time, particularly as to the vocabulary and problem-solving parts. Also transfer- and long-term effects should be taken into account.

STUDY 2

Introduction

Resarch-questions for this study were about the same as for the first study. Now, however, transfer effects were accentuated. Furthermore, an attempt was made to discern good and bad regulating processes, using Kuhl's theory on mind- and activity-orientations. The categorization-scheme was extended with mind-oriented processes (directed to failure or success experience or valuations of the task at hand, e.g. "This is too difficult for me" or "I hate these sums"), and task-irrelevant statements (distractions). Moreover, processing-measures were related to impulsivity, concentration-ability, verbal intelligence and motivation. Finally, students from a school of special education were the subjects of this study.

METHOD

Subjects

The Ss were 10 boys from a secondary school for special education. They were selected because of their weak concentration abilities. Ages ranged from 12 to 14 years.

Materials

In this study arithmetic word problems formed the main learning materials. Because of the learning disabilities of the Ss, the tasks used in study 1 could not be used. Arithmetic word problems were chosen because of the difficulties they pose for this kind of pupils (according to the teachers). We wanted to restrict the training to one type of task in order to prevent confusions between strategies for different tasks. In total 11 word problems like the following constituted the training material: " A train departs at 21.47 hours. Traveling time is 3 hours and 36 minutes. At what time will the train arrive?". Another set of 7 of these story problems formed the pretest and still 7 more were the posttest. Also, both at the pretest-session and at the posttest-session transfer-tasks were administered: 12 fraction-problems like 4/..=6/9 and 2 problem-solving tasks.

These tasks consisted of a description and a drawing of a route to be taken, for instance from school to home. On the way some other things had to be done, like visiting a library, shopping, delivering something to a friend. Several time-constraints as to how long a certain route takes, how long you need for a task or when something had to be done (e.g. the shop closes at 18.00 hours) form the data to be used. The Ss task is to find the fastest way home.

The following standardized tests were used: a concentration test (Bourdon-Wiersma), an achievement test (PMT-K), de Matching Familiar Figures Test (MFFT) and the verbal analogies-scale from an intelligence test (DAT).

The training program was like the one in study 1. Now, however, concentration problems were discussed, too. Feedback was intensified by recording problem-solving on video and discussing the recording with the Ss.

Procedure

There were 4 phases in this study. In the first individual session (taking 2 hours) the tests were administered. Also Ss were trained in thinking aloud, using materials comparable to the ones used in later phases.

The second phase constituted the pretest-session (1,5 hours). Now, the arithmetic word problems and transfer tasks were administered, subjects thinking aloud all the time.

In the third phase only half of the Ss participated. As a group they were trained during two sessions (4 hours in total).

Finally, the individual posttest-session took place. All 10 Ss again solved 7 arithmetic word problems and the transfer problems, thinking aloud all the time.

Design

The design was a pretest-posttest- control group design with random assignment to the two conditions.

RESULTS

Table 2 presents the differences in processing between good and weak Ss. As to the arithmetic wordproblems no significant differences appeared, though weaker Ss uttered somewhat more mind-oriented and distracted statements. For the fractions differences showed up as to execution and control. The difference in frequency of mind-orientation was not significant. For the problem-solving-task a similar phenomenon showed up, but now in the reverse direction. Good students had higher frequencies in these processes than weaker Ss. Overall the mean number of mind-oriented and distracted cognitions were rather low.

Table 2: Mean frequencies of processes for good and weak Ss

Processes	Arithmetic wordproblems		Fractions		Problem solving	
	good	weak	good	weak	good	weak
Execution	20.5	24.0	19.6	39.0**	17.4	5.8*
Control (1)	12.8	13.3	8.6	26.0*	14.6	4.6*
Mind-orient.	5.3	8.5	4.4	11.6	1.4	0.2
Distracted	1.8	2.5	3.8	3.8	4.8	0.6

(1) Control= A pooling of monitoring, regulation, testing (etc)
**=p< .05
* =.05<p<.10

Differences between good and weaker students covaried with the Matching Familiar Figures scores (word problems and fractions).(see table 3).

Table 3: Mean differences between good and weak Ss on testscores.

Tests	Arithmetic wordproblems		Fractions		Problem solving	
	good	weak	good	weak	good	weak
Achievement motivation	4.8	5.3	4.0	5.6	6.0	3.6
Intelligence	13.8	15.0	12.6	16.0	14.6	14.0
Concentration errors	25.0	31.0	27.4	29.4	22.4	33.8
Impulsivity	4.5	6.8*	4.6	7.0*	5.8	5.8

* .05<p<.10

Substantial correlations between process-frequencies and testscores were obtained for the arithmetic word-problems: impulsivity correlated with the number of mind-orientations (r=.64, p<.05) and the number of execution-statements (r=.58, p<.10). The time needed for the concentration-test correlated with the number of distraction statements (r=-.64, p<.05). Intelligence (r=.63, p<.10) and achievement motivation correlated with the number of mind-orientaions. For the fractions only the correlations between impulsivity and the number of executions and the number of control-processes were significant (r=.67, p<.05 and r=.69, p<.05, respectively).

The training program failed to be effective, as may be seen from table 4. None of the analyses of covariance with pretest-scores as covariates and posttest-scores as dependent variables reached statistical significance. Performance increased both in the training and in the control group. Process-data changed in an unintended direction. In the trained group a (non-significant) increase, instead of a decrease in the mean number of mind-oriented and distracted statements appeared. Since there was no effect on the process- and performance-data of the arithmetic wordproblems, no transfer to the fractions and problem-solving tasks showed up, as could be expected.

Table 4: Mean pretest and posttest results on word problems in the trained and untrained groups.

Variable	Trained group pretest	Trained group posttest	Control group pretest	Control group posttest
Performance	2.0	3.2	1.8	3.0
Execution	21.0	24.2	25.0	21.6
Control	12.2	13.0	15.8	13.2
Mind-oriented	5.4	8.4	9.6	8.0
Distracted	3.8	8.8	1.6	3.6

DISCUSSION

This study revealed some differences in regulation-processes between well and less well performing Ss. The differences in mind-orientation and distractability that we had expected were, however, too small to be significant statistically. The scores for mind-orientation and distractability were rather low. Training failed to be effective this time. No effects of training on performance or process-data were found.

The process-data on the fractions and problem-solving task seem to suffer from the cause and effect problem discussed before in a previous section. The fractions posed such great problems for some of the Ss that they tried over and over, noticing negative interim-results and being rather mind-oriented. The problem-solving task on the other hand was so difficult for some Ss that they did not do anything at all: processing stopped without hardly any verbalization. It seems then that differences in processes depend at least partly on the (subjective) difficulty of the task.

We did not succeed in finding a suitable operationalization for distractability. Students who were selected because of their concentration-problems verbalized few task-irrelevant cognitions. This might be an artefact of the thinking aloud procedure. Probably the necessity to verbalize keeps students concentrated. In spite of this, still a significant correlation with the concentration-test showed up.

The number of mind-orientations was also rather small. This may have to do with the fact that they were operationalized on the level of single statements. Kuhl, however, defined the distinction between mind- and activity-orientation on a more molar level. He defined activity-orientation as a state of mind in which both the present state, the goal state , the difference between these two and the possible actions get attention from the subject and mind-orientation as a state of mind in which a fixation on one of these four elements occurs. Perhaps then a more holistic approach in analyzing protocols should be preferred.

Whereas in the previous study with "normal" Ss at least some effects of training showed up, in this study with students with learning problems no significant training effects were obtained. This might have to do with the difference in subject-populations. Perhaps for children with learning problems training should take more time or should differ in approach (for instance as in the succesful program of Palincsar and Brown, 1984).

STUDY 3

Introduction

In this study an attempt was made to solve some of the problems encountered in the previous one. Mind-orientation was operationalized differently. Instead of registering single mind-oriented statements, now patterns of statements were sought that might be indicative of mind-orientation. Therefore, there was no separate category for mind-oriented verbalizations. The training program was changed considerably by incorporating new elememts like reciprocal teaching procedures (Brown & Palincsar, 1984), individual learning goals based on protocols collected during a pretest session and modeling. As a consequence of this, the training took about twice as much time as in the previous studies.

METHOD

Subjects

The Ss were 4 boys and 2 girls from a school of special education, selected out of a group of 45 students on the basis of 6 criteria: weak concentration according to the teacher and the schoolpsychologist, impulsivity (MFFT), age (12 years old), low achievement motivation, high test-anxiety and sufficient mathematical ability.

Materials

As in study 2, arithmetic word problems formed the learning material. For the pretest 3 word problems were used, as was done for the posttest. Reading-comprehension was used as a transfer measure. Both during the pretest-session and during the posttest-session Ss studied a text of 3 pages (one on "old times", the other on "the parents-evening") and answered open-ended questions about its contents.

For all Ss individual learning goals were formulated on the basis of their pretest-protocols. For each individual training session a script was prepared, concretizing how the individual learning goals could be reached. The elements included in the training were: reciprocal teaching procedures, experimenters and students changing roles, modeling, awareness training, direct instruction on regulation mechanisms, prompting, and feedback on regulation processes. In two group sessions (N=3) students worked together and discussed their regulation processes.

Procedure

The first session was a pretest-session. It started with a practice in thinking aloud when solving a wordproblem. Ss were taught how to think aloud, receiving feedback. Then the three wordproblems were solved thinking aloud. During the second session, the text was read, again thinking aloud. Directly afterwards 8 comprehension-questions were answered on the content of the text. The third session took place after 10 days and constituted the first individual training session. In between the thinking aloud protocols were typed out and analyzed in order to formulate the individual learning goals. This session was devoted to awareness-training, following the procedure used in study 1. The fourth session (2 days later) also was an individual session. Now three word problems were solved, following a reciprocal teaching procedure. Two days later a group session (6 students and 2 experimenters) followed. Regulation-processes were modeled by the experimenters. Students were stimulated to work together and to be each other's external monitor. Also, important conclusions from the individual sessions were repeated and discussed. The sixth and seventh sessions again were individual training sessions, the procedure being the same as in the fourth session. Different kinds of word problems were used as training materials. The eighth session was another group-session (like session 5). Students now learned the differences between five kinds of wordproblems. Furthermore they wrote down what they thought they had learned from the training. The final session was the posttest-session, and identical to the first session.

Design

The design was a pretest-posttest design. Due to practical circumstances no control group could be used.

RESULTS

The training resulted in a significant increase in scores on the arithmetic wordproblems (from 2.1 to 5.5, $t=2.50$, p(one-tailed) $<.05$). Transfer to the text comprehension performance, however, did not occur (M-pretest 4.9,M-posttest 4.9, n.s.).

In table 5 frequencies of the different processes per subject are presented, both for the pretest and for the posttest-session. Ss 2 and 5 increased their number of verbalizations in almost all categories. These were also the 2 Ss profiting most from the training in terms of performance improvement. Ss 4 and 6 increased their number of execution-, regulation- and testing-statements. Subject 1 increased its number of execution and testing verbalizations and for subject 3 an increase in the number of orientation and regulation statements could be noticed and a decrease in the number of monitorings. These changes did not occur as to the verbalizations during text comprehension, as may be seen from table 6.

Table 5: Frequencies of the different processes, before and after training (arithmetic wordproblems).

Subject	1		2		3	
Process	pre	pos	pre	pos	pre	pos
Execution	18	32	25	65	58	57
Orientation	11	11	7	16	8	12
Monitoring	20	20	11	44	31	21
Regulation	13	11	6	30	24	29
Testing	2	8	2	11	5	1
Diagnosing	--	1	1	1	--	--
Evaluation	--	--	1	--	--	--
Distracted	4	2	1	--	--	--

Subject	4		5		6	
Process	pre	pos	pre	pos	pre	pos
Execution	7	23	5	230	1	18
Orientation	--	1	--	55	5	2
Monitoring	--	4	4	164	10	7
Regulation	4	14	8	93	2	8
Testing	--	6	--	32	--	2
Diagnosing	--	--	--	7	--	--
Evaluation	--	--	--	2	--	--
Distracted	--	--	--	5	--	--

Table 6: Frequencies of different processes, before and after training (text-comprehension).

Subject	1		2		3	
Processes	pre	pos	pre	pos	pre	pos
Execution	26	33	30	47	34	33
Orientation	5	5	4	6	9	6
Monitoring	7	10	16	22	19	13
Regulation	--	7	10	13	11	5
Testing	1	1	2	6	1	3
Diagnosing	--	1	--	--	1	--
Evaluation	--	--	--	1	--	--
Distracted	3	--	--	2	--	--

Subject	4		5		6	
Processes	pre	pos	pre	pos	pre	pos
Execution	24	39	33	30	12	37
Orientation	1	--	4	5	4	8
Monitoring	5	4	23	20	9	11
Regulation	15	15	20	17	5	21
Testing	--	--	--	2	--	1
Diagnosing	--	--	1	--	--	--
Evaluation	--	--	--	2	--	--
Distracted	--	--	--	5	--	--

In order to find changes in mind- and activity orientation, the thinking aloud-protocols were analyzed per word-problem and classified according to the 4 kinds of fixations discerned by Kuhl and mentioned in the introduction. The results are presented in table 7. There were more activity-orientations after training (chi-square=6.9 ,$p<.01$).

Table 7: Classification of wordproblem protocols according to mind- and activity-orientation

Orientation	pretest		posttest	
Mind-orientation	16		7	
Goal-fixation		11		3
Failure-fixation		3		3
Planning-fixation		2		1
Activity-orientation	2		8	
Unclassifiable	-		3	

The number of negative and positive self-statements were also counted.The number of negative self-statements decreased from pre- to posttest for 3 Ss during the solution of the wordproblems and for all Ss during text comprehension. There were no increases in the number of positive self-statements.

DISCUSSION

The training this time did have an effect on performance, though transfer to the reading task did not show up. Of course we cannot be certain that the increase from pre- to posttest was caused by the training, since there was no control group. Since, however, differences between the thinking aloud protocols of the pretest-session and the posttest-session, that could be related to the training, were also observed, we have some confidence that there were real training effects. Furthermore, the Ss stated that they learned a lot from the training.

Finally, it should be noted that we do not know which elements of the training were responsible for the obtained effects. Further research is needed to clear this up.

CONCLUSIONS

In spite of some methodological problems (like the influence of task-difficulty) still some interesting individual differences in control processes could be discerned. These differences pertained to the quality and quantity of testing, the breadth of orientation, the amount of on-line regulation, mind-versus activity-orientation and distractability. Under specified circumstances these differences correlated with performance differences and testscores (especially impulsivity). It seems possible to change these individual differences through training, even in students with severe learning problems. The exact nature of optimal training remains, however, somewhat unclear.

Further research is needed on the questions underlying the studies reported. In our present studies thinking aloud protocols are collected in greater samples of Ss, using training programs of longer duration and also addressing the methodological issues mentioned before.

Footnote

1) The studies reported in this paper were executed by the following students of psychology: Jan Vermunt (study 1), Ingrid Eijkelkamp and Connie Senden (study 2) and Antoinette de Bot and Mu~iël Daal (study 3).

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APPENDIX 1: Definition and examples of main categories of processing activities

CATEGORY	DEFINITION	EXAMPLES
1. Execution	all cognitive and overt activities transforming states of knowledge or understanding in the direction of aimed states	- reading - I don't think this is an experiment
2. Monitoring	perceiving, interpreting noticing characteristics of executed actions	-oh yes, I understand - this is very difficult
3. Regulating	choosing activities and objects on which activities should be performed	
3.1. Planning	regulation on a macro-level before text processing	- if I read this very thoroughly I shall understand it
3.2. On-line regulation	regulation during text processing	- I'll just read on, perhaps I shall understand it later
4. Orienting	preparing oneself for the task by inspecting the learning situation, possible activities, goals and own characteristics	- will there be a test? - oh, I'm very good at multiple-choice tests
5. Testing	all activities leading to information about results of learning	- yes, this seems to follow from this table
5.1. Testing on understanding	all activities leading to information on understanding	- paraphrasing
5.2. Testing on knowledge	all activities leading to information on knowledge	- reproduction of text-fragments without reading
6. Diagnosing	looking back at a preceding learning process in order to discover why results are (not) reached	- I just don't understand how this figure has been constructed, but that is because I am no good at mathematics
7. Evaluating	judging the total learning process in relation to the goals	- no, I don't understand all of it, but enough to pass the test

APPENDIX 2: Scheme of (sub)categories used in protocol analysis

1. Execution
   1.1. reading
   1.2. rereading
   1.3. imprinting
   1.4. addition of information
   1.5. comments
   1.6. asking for explanation

2. Monitoring
   2.1. noticing positive interim-results
   2.2. noticing negative interim-results
   2.3. noticing characteristics of the task
   2.4. noticing own actions

3. Regulation of the learning process
   3.1. planning
   3.2. on-line regulation
   3.2.1. choosing new activities
   3.2.2. selecting information for extra attention
   3.2.3. a combination of 3.2.1. and 3.2.2.

4. Orienting
   4.1. exploration of text
   4.2. asking for information on goals
   4.3. reflection on own characteristics
   4.4. actualizing knowledge on possible actions

5. Testing
   5.1. testing on understanding
   5.1.1. paraphrasing
   5.1.2. comparing on internal consistency
   5.1.3. comparing own conclusions with text
   5.1.4. solving example problems
   5.2. testing on knowledge
   5.2.1. reproducing
   5.2.2. comparing reproduced knowledge with text
   5.3. checking of solutions of problems
   5.4. generating questions

6. Diagnosing
   6.1. relating results to characteristics of the task
   6.2. relating results to actions
   6.3. relating results to own characteristics
   6.4. specifying learning results

7. Evaluating