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Training Metacognitive Processes of Self-Regulated Learning

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In the late 1970s several aptitude treatment interaction (ATI) studies were done in the Department of Instructional Psychology of Tilburg University. In three different series of ATI studies a common pattern of results emerged. Lodewijks (1981) showed that students learning science concepts in a self-chosen sequence performed better than students learning these concepts in a carefully prepared predetermined sequence. Intelligent students profited more from the opportunities for self-determination than the less intelligent ones. Simons (1984) found that some students performed better without than with concrete analogies that aimed to facilitate understanding of concepts. Likewise, Van der Sanden (1986) showed that some students (especially the better performing and more intelligent ones) performed better on a practical construction task without instructions than with detailed and explicit advice. In general, then, for at least some of the students, extending the opportunities for self-regulation could increase learning performance. Therefore, we decided to start a new research project focusing on self-regulation in learning.

The clearest demonstration of self-regulation in learning occurs when students have ample opportunity to make their own preparations, executing the actions independently, regulating themselves, making their own performance judgments, giving feedback to themselves, and keeping themselves motivated and concentrated. Most of the time, however, third persons (parents, 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 and responsibilities. Hardly anyone learns completely independently of others. On the other hand, there is some opportunity for self-regulation in almost every situation, albeit only decisions as to speed of working or effort expenditure.

According to the studies mentioned previously, improvement of performance might be reached by giving students more opportunities to regulate their own activities and to bear responsibility for their own learning. Since this is often problematical in practice, a few problems should be mentioned. Apart from the students who might profit from these opportunities, there are also those who will perform (even) worse when left alone (Lodewijks, 1981; Van der Sanden, 1986). Students who are not used to freedom and responsibility may not have the capabilities needed for independence. Students may not believe that they are capable of self-regulation. Students may dislike responsibility. Teachers may hesitate to hand over responsibility to their students. Larsson (1983) discussed these kinds of conceptions, circularities, and paradoxes in the context of the division of tasks between teachers and students: 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.

What seems to happen in many instructional situations is that teachers feel obliged to take over learning activities, because they observe that students are not able to execute them on their own. For instance, teachers expecting their students to make their own notes, using their schematizing and structurizing abilities, soon discover that many of the students are not able to make adequate notes. Then they feel obliged to take over by literally dictating the notes. Because of this, these students never learn how to take notes independently and the circle closes.

An important lesson to be learned from all of this is that much more is needed than just giving opportunities for independent work: metacognitive knowledge must be acquired, conceptions must be changed, and regulatory activities and regulatory processes must be learned. In our opinion, there is only one way out of the paradoxes and circularities discussed and that is by training students in self-regulation. Training programs should have at least three goals:

1. Convincing students that they have their own responsibility and that they are capable of regulating their working, problem solving, or learning.
2. Training students in how they can regulate their own learning.
3. Training students in how to execute relevant learning activities.

In the third part of this chapter several training studies are reviewed.

In devising a training program one has to know which knowledge and activities constitute self-regulated learning. Our approach in gaining insight into the knowledge and skills that are important in self-regulated learning and that should be included in training programs has been to study the differences in processing between students performing well on independent learning tasks and those who perform less well. The method of data collection used in these studies has been the method of thinking and learning aloud. Several of these studies are reviewed in the next section of this chapter.

The data of the thinking-aloud protocols are analyzed in four general regulation categories: orientation, monitoring, directing, and testing. Each category consists of several processes (see table 7.1; see also

De Jong, 1987). A fifth category, called transforming, concerns verbalizations that indicate mediation activities. By these activities the information is transformed into information in the student's mind. One can think of activities like reading, drilling, copying, calculating, and adding information, drawing on previous school learning or one's own experience (e.g., "This key is on the other side of the keyboard of my own computer"). A sixth category, off-task remarks, deals with the experimenter's stimulations and other remarks by him or by the subject.

The category *orientation* includes processes that are aimed at gathering information about the learning task (orientation before learning) or the problem situation during learning in order to select, allocate, or change ongoing learning activities. Examples of orientation processes are glancing through the task, mentioning one's normal study strategy, reflecting on positive or negative student characteristics, and reflecting on the foreknowledge or gaps in it.

Monitoring processes function as the finger on the pulse. Verbalizations are the reflection of keeping an eye on the proceeding of one's own learning process. They are a kind of "learning watchers." Examples of monitoring processes are noting positive or negative interim results, task characteristics, uncomprehended words, sentences, or text fragments, and remainder of study time and making an interim evaluation.

Processes covered by the category *directing* express management of the learning behavior by the student. One can think of process selection and allocation (planning), problem identification, selecting information as an object of attention, dividing a problem into subproblems, asking oneself questions, ignoring an uncomprehended word, or expecting that clarification will follow. Even rereading, if not preceded by a statement like "I'm going to reread that" (process selection), expresses a directing of one's learning processes.

Testing is the category with processes used to check whether one has acquired information or comprehension or to check whether learning goals have been reached. Processes like paraphrasing, summarizing, drawing conclusions, solving exercises, and recalling and comparing text fragments are covered by this category.

The main research question for the studies reviewed in the next section was "What (combinations of) categories and processes differentiate between students performing well and weakly?"

Differences in Self-Regulation Between Students Performing Well and Performing Weakly

Study 1

In a first study (Simons & Lodewijks, 1987), employing 14 students from first grade, three tasks were used: a text to be studied, some chance problems to be solved, and a list of foreign vocabulary to be learned. The thinking-aloud protocols were scored according to the categories, and processes mentioned earlier. For each task the frequencies of the categories and processes of the seven better performing students were compared with those of the seven weaker students.

There were no differences in frequencies on the main categories between good and weaker students in text processing. However, within the testing category a significant difference showed up. Good students tested more frequently on understanding than did weaker students. Weaker students, however, tested more often on knowledge. Thus not the quantity but the quality of testing differentiated good from weaker students. Successful students tested in a way that was tuned to the learning goal, whereas less sucessful students tested on memory.

In vocabulary learning, however, the quantity of testing was the differentiating variable. Better students tested three times as often as weaker students.

Differences between good and weaker students for the problem-solving task related to the total number of processes registered and the number of monitoring, direction, and orientation processes. Better students monitored, directed, and oriented more than weaker students.

Studies 2 and 3

The number of subjects in study 1, however, was rather small. Therefore, we wanted to start a study with a greater number of students, aiming at replicating these results in a larger sample. In addition, we wanted to study the qualities of the thinking-aloud method in studying self-regulation. Thus an ambitious research project, called Self-Diagnostic Learning, was started; the objective was to trace the learning activities by which successful students regulated their learning (see De Jong, 1987; De Jong & Simons, 1988). During the first two years two studies were set up in order to examine the differences between successful and less successful students in their use of learning activities and regulation processes. Again thinking-aloud protocols were assembled.

In study 2 (N = 68) students from the seventh grade (12 and 13 years of age) learned four different learning tasks: learning a vocabulary list of 40 words with the purpose of translating them from English into Dutch and the reverse, representing learning by heart; learning an expository text with a biological subject "burns" and "hair", learning a text about theory of chances and calculus of probabilities representing "problem solving"; and learning a text about the keyboard and the editor of a computer in order to apply the information of the text, representing learning tasks of which the main goal was the application of given information. In this study we also examined whether students think aloud easier or not with or without marks in a text to remind them to think aloud. One problem we expected when using the no-marks condition was that the number of verbalizations would drop. Therefore, students learned two versions of each learning task, one with marks and the other without marks. Another studied was the generality of instructions about what and what not to verbalize. Half the subjects received general instructions about the kinds of thoughts they were expected to verbalize; the other half received more specific and concrete instructions with many examples. We would prefer the specific instructions but were afraid that too specific instructions would trigger certain verbalizations that would comply to the instructions instead of the thinking processes.

The study showed that there were hardly any differences between the marks and no-marks and the general and specific verbalizing instructions. The only difference found was that some kinds of statements (noting task features) were repeated when there was a mark. A combination of no-marks and specific instructions, therefore, seems to be the best solution. There were significant differences between successful and less successful students in regulation processes, especially with reference to the categories of monitoring, directing, and testing. These results, however, were contaminated by one of the conditions (generality of instructions). The learning tasks were not presented in a counterbalanced order. Thinking-aloud data predicted learning results better than any other variable measured such as student level, competence, metamemory, and metacognition (measured by student's predictions of their learning results), learning conception (see Vermunt & Van Rijswijk, 1988), and reading succession (see De Jong, 1987; De Jong & Simons, 1988).

In the second year, a third study was carried out in order to examine whether these differences between the successful and less successful students in the use of regulation learning processes could be replicated when variations in marks versus no-marks and general versus specific instructions were left out and with a counterbalanced design. Based on the results of the second study we chose the no-marks and the specific instructions. The same learning tasks as in the second study were used with 36 students participating. Again thinking-aloud protocols were recorded and 144 protocols were analyzed. In general, the results of the prior studies were replicated. Thus successful students monitored, directed, and tested significantly more often than less successful students. The patterns of regulatory processes again were rather task-dependent.

The most striking result of the last two studies was the fact that subsets of regulation processes explained high percentages (between 19 and 60%) of the variances in the learning results of the different learning tasks. Processes of the categories monitoring, direction, and testing were particularly well represented in these subsets. Another striking fact is that few orientation processes took place, with either successful or less successful students. As shown by these studies, students often fail to adequately plan and make adjustments beforehand. Only when they encounter problems do they start to think. Few students monitor, test, and check their learning processes in a way that is tuned to the learning goals. Revision mechanisms (like reorientation or new planning) showed up only very rarely. Students who did monitor, direct, and test, however, tended to perform better than the other students. Furthermore, the number of negative self-statements correlated negatively with learning performance.

Studies 4 and 5

In a fourth study (see Simons, 1989) we tried to expand on this last aspect (negative self-statements), using Kuhl's (1983) theory on mind and action orientations. According to this theory, in ideal mental states (action orientation) attention is divided evenly among (1) the beginning state, (2) the goal state, (3) the discrepancy between the present state and the goal state, and (4) the path that leads from the beginning state to the end state. In mind orientation, however, attention fixes on one or two of the four components of a fully developed action structure. Kuhl discerned four kinds of fixations (or four kinds of mind orientation): goal fixation, planning fixation, failure fixation, and success fixation. The categorization scheme was extended with mind-oriented processes (e.g., "This is too difficult for me" or "I hate these sums") and task-irrelevant statements or distractions (e.g., "Tomorrow is my birthday"). Moreover, processing measures were related to impulsivity, concentration ability, verbal intelligence, and motivation. Ten students from a school of special education were the subjects of this study. Ages ranged from 12 to 14 years. Arithmetic word problems formed the main learning materials. Two other kinds of tasks were administered: 12 fraction problems like $4/x = 6/9$ 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, the time needed for a task, or when something had to be done (e.g., the shop closes at 18.00 hours [6 o'clock]) form the data to be used. The students' task was to find the fastest way home. Because of the learning disabilities of the students, the tasks used in the other studies could not be used. A set of seven story problems like the following formed the pretest and another seven were the posttest: "A train departs at 21.47 hours [9:47 PM]. Travel time is 3 hours and 36 minutes. At what time will the train arrive?"

On arithmetic word problems no significant differences appeared between better and weaker performing students, although there was a tendency for the latter to utter somewhat more mind-oriented and distracted statements. For the fractions differences showed up on transformation and regulation (a pooling of the categories monitoring, testing, and directing): weaker performing students regulated and transformed more than the better performing ones. The difference in frequency of mind orientation again was not significant. For the problem-solving task a similar phenomenon showed up, but now in the reverse direction. Good students now had higher frequencies in the transformation and regulation categories than did weaker students. Overall, the mean number of mind-oriented and distracted cognitions was rather low. Substantial correlations between process frequencies and test scores were found: impulsivity correlate with the number of mind orientations and the number of transforming statements. The time needed for the concentration test correlated with the number of distraction statements. Intelligence and achievement motivation correlated with the number of mind orientations. The differences in mind orientation and distractibility that we had expected to find were too small to be significant statistically. The scores for mind orientation and distractibility were rather low.

The process data on the fractions and problem-solving task seem to suffer from a cause and effect problem. The fractions posed such great problems for some of the students 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 students that they did not do anything at all: processing stopped with hardly any verbalization. It seems, then, that differences in processes depend at least partly on the (subjective) difficulty of the task.

The number of mind orientations was rather small. This may be related to the fact that they were operationalized on the level of single statements. Kuhl, however, defined the distinction between mind and action orientation on a more global level. He defined action orientation as a state of mind in which both the present state and 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.

In a fifth study (see Simons, 1989) this more global approach was attempted with thinking-aloud protocols of six students from a school of special education. For each subject (12–14 years of age) we collected three protocols of word problem solving. According to the more global approach employed, 2 of these could be classified as action-oriented, the other 16 were mind-oriented; 11 had a failure fixation, 3 a goal fixation, and 2 a planning fixation.

Conclusions

From the studies that investigated individual differences in self-regulation processes that correlate with performance on tasks that had to be executed relatively independently, it became clear that such differences do exist, at least in the population of students studied (seventh grade, 12–14 years old). Differences in testing monitoring, and directing explained high percentages of variance in performance differences. The patterns of subprocesses within these main categories, however, were complex and task-dependent. The differences in action and mind orientation could not be found by looking at single statements. But the last study suggests that in a more global approach on the level of patterns of statements, such differences could be found in thinking-aloud protocols. Clearly a replication in a much larger sample is necessary.

Training Studies

Training Study 1

In designing training programs we had the following starting points:

1. We based the training on the differences in processes observed during a pretest session.
2. We stressed metacognitive awareness by letting students reflect on their own way of learning and that of other students.
3. 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, self-testing).
4. Noncognitive variables like concentration, self-motivation, attributions, and mind orientations were also included when possible.

Typically and uniquely in our attempts, thinking-aloud protocols are used as the dependent measure in addition on the normally employed learning performance measure. The design of the studies, to be reviewed shortly, was in all but one of them as follows. Subjects thought aloud and filled in a pretest and some questionnaires. The data of the thinking-aloud protocols collected during the pretest sessions were reported under the heading of individual differences in the previous section. Thus three of the studies reported here employed the same subjects as the individual differences studies reported previously. Based on these data (sometimes only on a preliminary and superficial inspection of the protocols, because of time constraints) the training programs were devised and executed, employing different learning materials. Then at a posttest session parallel to the pretest session, thinking-aloud protocols were collected and posttests, transfer tests, and questionnaires were filled in a second time.

In the first study (reported in Simons & Lodewijks, 1987) a relatively short training (three sessions only), focusing on metacognitive processes, with eighth graders ($N = 14$) of relatively high intelligence, proved to be effective. The subjects, being the same as those in study 1 discussed in the previous section, came from so-called HAVO-VWO (comprehensive) schools that accept only the top 30% of the student population, using performance on primary school and intelligence as admission criteria. The headmaster was asked to select the seven students who would need training the most. The trained students increased both their number of text comprehension testing processes and their text learning performance, whereas the control subjects remained at the same level as before. The training was not successful, however, as to vocabulary learning and problem solving.

Training Studies 2 and 3

Simons (1989) reported two training studies with children from special education, learning to solve word problems. Here the subjects, being the same as those in studies 4 and 5 in the last section, were students with learning difficulties (especially concentration problems). In the second training study ($N = 10$) the students were randomly divided over a control group and an experimental group. The training, having a duration of 4 hours, failed to have any effects: there were neither changes in the thinking-aloud protocols nor changes in learning performance, in either the experimental or the control group.

The third training study ($N = 6$) had a much longer (10 hours) and more intensive training, but no control group. Now there were increases in both word problem-solving and regulation processes. The number of mind-oriented patterns decreased significantly, as did the number of negative self-statements.

From these first three studies we concluded that it seems possible to make students more active learners, but that it takes a lot more time and energy to do so with learning-disabled students.

Training Study 4

We decided to set up a new training study with a much longer duration (nine sessions) and with students without learning disabilities. An executive control training embedded in extra exercises for low-achieving pupils in a mathematic course of a comprehensive school was set up (De Jong, 1990). The study used a pretest–posttest control group design, with 26 students (12 years of age) of a HAVO/VWO school participating in the study. Regulation processes were recorded by the thinking-aloud method and protocols were analyzed in order to assess the effect of the training on executive control. Metacognitive knowledge was measured by a situational questionnaire.

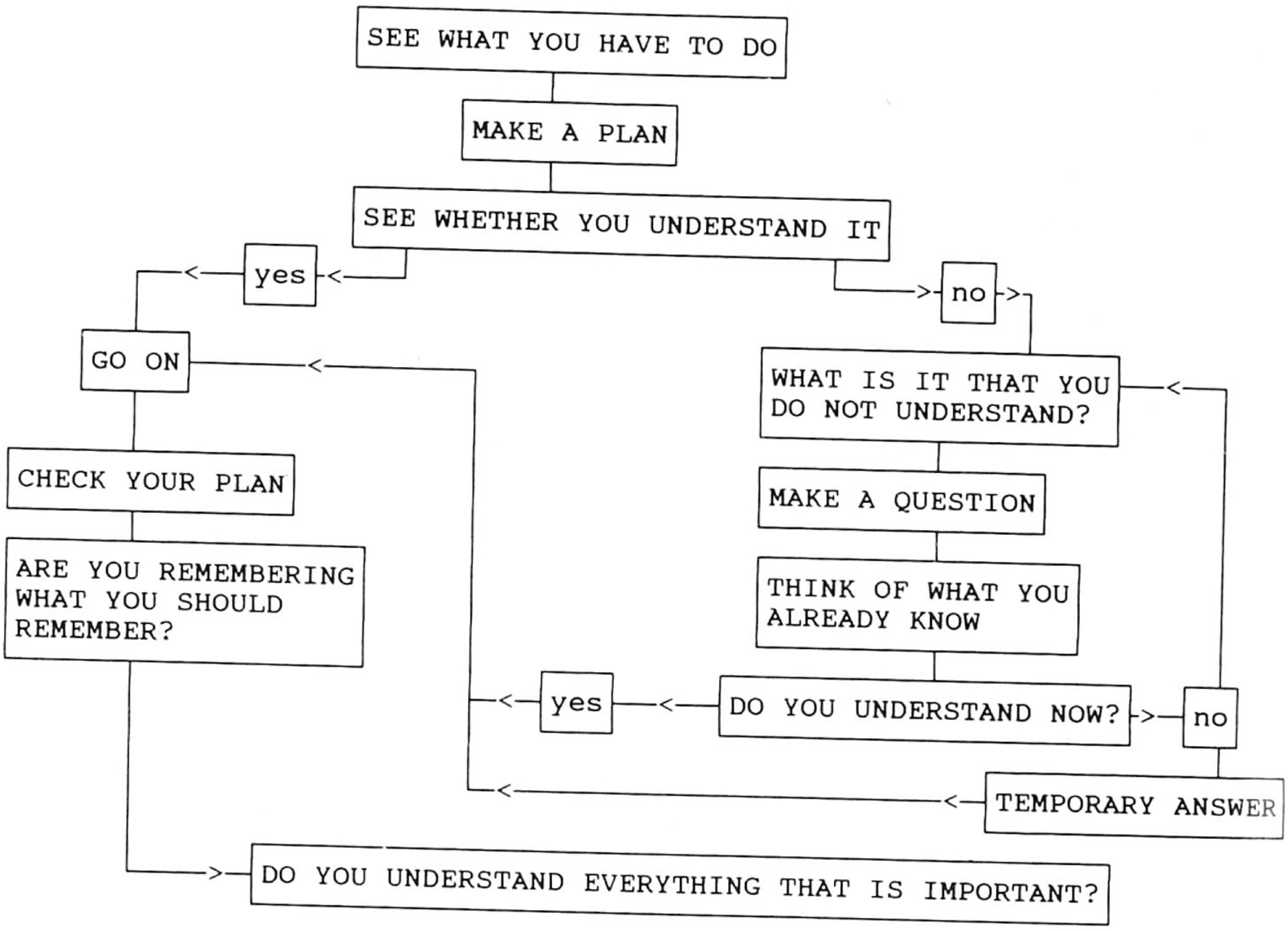

FIGURE 7.1. Heuristic of active learning and regulation processes.

During the first three of the nine sessions students were stimulated to increase their metacognitive knowledge. These awareness sessions were filled in by contrasting their statements on the situational questionnaire to the statements of a prototypical successful and less successful student. In the questionnaire students had to write down what they would do in some described hypothetical mathematics homework situations. The statements of the prototypical successful student were directly derived from a learning heuristic (see Figure 7.1). This heuristic in its turn was developed on the basis of the best subset of regulation processes. It included those orientation, monitoring, directing, and testing processes that we had found to have an impact on the learning performance in studies 2 and 3 mentioned in the section on individual differences. The learning heuristic was composed of three layers. The first layer consisted of a flow chart with several processes to execute when regulating your own learning and reading. One of these is, for instance, the process "Check whether you understand what you read." The processes were presented in an almost serial way and an imperative mood. In the second layer the parts of the diagram were translated into questions that have the function of triggering adequate executive control processes. For instance, the processes mentioned above became "What exactly do I not understand in what I have been reading?" In the third layer information was provided about *what* is meant by each question, *how* one can answer or realize it (concrete activities), and *why* one should do it at all. This learning aid was presented to the students in a booklet called, "You can do your homework on your own."

During the next six sessions interventions and controlling took place by a human tutor when students were solving the extra exercises. During the first session a modeling situation existed, in which the tutor first solved one of the exercises and the student followed him in the outline of the heuristics. After that the roles were reversed. During the other sessions students were confronted with layer two and/or three of the learning aid and forced to remember the hints or read them when they had made mistakes or just encountered a problem to solve during the problem-solving process. Thus the experimenter did not give any content information. He just pointed the student at his failure of adequate executive control by asking: "Where are you in your learning process and what kind of regulation processes are important then to execute?" Performance tests consisted of one multiple choice test and nine chance problems (probability calculation) to solve.

The training had a significant and positive effect on students' metacognitive knowledge, the scores on the situational questionnaire, and the actual regulation processes (as showing up in the thinking-aloud protocols) of the training group in contrast to the control group and the pretest scores. There was a significant increase in the main category of testing: subjects in the experimental group tested more often at the posttest session than at the pretest session and than the control group. The following processes increased in frequency in the experimental group and not in the control group: drawing correct conclusions, text comparison, recalling, noting task features, choosing learning activities, questioning oneself, and answer checking. The training also had positive effects on the learning performances of the training group. Performances of the experimental group during the training sessions were in three out of five sessions significantly better than those of the control group. The performance differences on the transfer test, however, did not reach statistical significance. The scores of the experimental group increased from 4.1. (SD = 1.6) on the pretest to 5.4 (SD = 1.7) on the posttest in contrast to the performances of the control group, M_{pre} = 4.5 (SD = 1.5) and M_{post} = 4.5 (SD = 1.8).

The Design of Training Studies 5 to 8

Encouraged by the success of training study 4, we decided to design more training studies, but now employing computer-aided instruction (CAI). These are summarized here and reported more fully in De Jong (in press), and De Jong and Simons (1990). The learning heuristic was built into two CAI programs and was labeled "Learning Aid." All these training studies used the same training approach, materials, and design.

The subject population, however, differed with reference to intelligence, school achievement, and the learning difficulties of the students. In three of the four studies the learning aid was presented through computer-aided instruction integrated in biology and history lessons. In one study the aid was integrated in a text comprehension curriculum, also as computer-assisted instruction. The flow chart (see Figure 7.1) was presented whenever study text was presented during the first four lessons. The two deeper layers could be consulted any time the students wanted to do so by a special key on the computer keyboard. At regular times the deeper layers also intervened as the learning aid without the student asking for it. It checked whether the student was using the heuristic and it posed nagging (in the students' eyes) questions to the students when they did not. Then the student involuntarily came to the third layer of the learning aid. These interventions were "scaffolded" during the last four sessions in that their frequency of occurrence was lowered; they finally stopped completely and were replaced by screen-filling prompts in order to enable recall and stimulate the execution of important regulation processes.

The research question for the four studies was: Does the learning aid affect learning and regulation processes and learning performance? An experimental group studied the learning material with the help of the learning aid and a control group did so without the learning aid. Before and after the training, students learned two texts as transfer tasks (in counterbalanced order, about "hair" and "burns," thinking-aloud). The sequences of sessions started with a training session in which students were trained to think aloud. The design in all four studies was a pretest–posttest control group design (with exception of study 8 in which no control group could be formed). Students were matched on the basis of verbal intelligence into two dummy groups; then persons of each level of the dummy groups were randomly assigned to the training and control group. The thinking-aloud protocols were audiotaped, transcribed, and analyzed through the scheme used in previous studies (see Table 7.1).

Training Study 5

In this study 40 students (12 years of age) from the first grade of a lower vocational school participated as subjects. There were 11 sessions: a thinking-aloud training session, the pretest and posttest sessions, and 8 learning sessions. The materials consisted of four biology lessons and four history lessons.

During the posttest session students in both groups used less regulating processes than during the pretest session. The expected condition effects failed to appear for all of the main categories and all but one of the subcategories tested. The only effect approaching statistical significance was in the process "rereading a word." The training did have a significant effect, however, on the learning performance measure. The average per-

TABLE 7.1. Process analyzing scheme.

Orientation	
D	Glancing through the task.
DL	Going through a subject list.
AS	Mentioning his or her normal study strategy.
RE	Reflecting on positive student characteristics.
RE−	Reflecting on negative student characteristics.
RV	Reflecting on foreknowledge.
RV−	Reflecting on gaps in the foreknowledge.
Monitoring	
CP	Noting positive interim results.
CN	Noting negative interim results.
CT	Noting task characteristics.
CH	Noting one's own activities.
TE	Interim evaluation.
COW	Noting uncomprehended words.
COT	Noting uncomprehended text fragments.
COS	Noting remainder study time.
Directing	
PL	Planning.
KA	Process selection.
SA	Selecting information as object of attention.
AP	Problem identification.
KD	Dividing a problem into subproblems for solving.
N	Ignoring an uncomprehended word by reading on.
W	After noting an uncomprehended word, reading further in the expectation that clarification will follow.
IV	Asking for information.
HW	Rereading a word.
HL	Rereading a text fragment.
AT	Anticipation on the test.
HT	Adapting one's learning to the remaining study time.
Testing	
P+	Paraphrasing in consensus with the text.
P−	Paraphrasing not in consensus with the text.
C+	Drawing a conclusion in consensus with the text.
C−	Drawing a conclusion not in consensus with the text.
VT	Comparing two or more text fragments.
VC	Comparing one's conclusions with the text.
R	Recalling.
RS	Recalling and writing.
V	Comparing the recall with the text.
VRV	Comparing the recall with the text and correcting.
SI	Making summaries.
SG	Making global summaries.

formance of the experimental group on the transfer test increased from 4.5 (SD = 1.6) to 4.8 (SD = 2.2), whereas that of the control group decreased from 4.1 (SD = 2.0) to 3.6 (SD = 1.6). The experimental group also outperformed the control group in sessions 6 and 7.

Training Study 6

In study 6 students ($N = 20$), being 12 years of age, came from the first grade from a special school for agricultural lower vocational education. The study was a complete replication of the previous one with the exception of the kind of subjects employed. There were no effects of training on any of the dependent measures.

Training Study 7

Because of the meager results of the previous studies a seventh study was set up in which the regulation training was embedded in a curriculum of learning how to identify the main ideas in a text (Aarnoutse, 1985). Regulation training took place during the time the students did their homework for this curriculum on the computer. The learning aid was integrated in their homework. The control group did their homework at home, as usual. A reading test to diagnose students' ability to identify main ideas in a text was added to the pretest and posttest sessions. A modified version of the situational questionnaire to measure metacognitive knowledge was added as posttest as well. Forty reading-disabled students (12 and 13 years of age) from a special school for agricultural lower (individual) education took part in the experiment.

There were, again, no significant differences in learning performance between the experimental and the control group. There were, however, some very small but nevertheless significant differences in the thinking-aloud data. In the experimental group the number of statements in the process of "noting negative results" and of "noting task features" decreased, whereas they increased in the control group. Furthermore, a significant difference between the experimental and the control group showed up in metacognitive knowledge.

Training Study 8

In the meantime, another regulation study was executed by one of our graduates with students in the last years of a VWO school (preparatory school for scientific education, accepting only the top 30% of the student population). The training used the same kind of heuristic and was integrated in a computer-aided instruction for teaching students to comprehend foreign (English) texts. This training study did have effects, even rather extreme ones, both on the learning performance and on the learning processes. With these older and more intelligent students, the training increased among other things the number of activities as looking for information and paraphrasing. It also increased the learning performances on a national examination (Biemans, Van Deursen, & De Jong, 1989).

This motivated us to try once again and to set up a fourth study with the same material as in studies 5 and 6 but with students having a much higher (verbal) intelligence and being much older. First-year students of a vocational economic and administrative school (MEAO) participated in this study ($N = 41$). The students were 17 and 18 years of age. The situational questionnaire was used again to measure metacognitive knowledge. A deviation from the studies mentioned previously is that no thinking-aloud protocols were recorded this time. Self-regulation was registered by means of two questionnaires. The first one was the Homework Approach Questionnaire (HAVT), consisting of descriptions of homework situations. Students had to indicate on a four-point scale how much a situation fitted to their own way of dealing with such situations (Van der Sanden, 1989). The test had three subscales: one for action orientation, one for mind orientation, and a third for self-regulation. The second, the Inventory of Learning Styles (ILS; Vermunt & Van Rijswijk, 1988) consisted of 88 five-point statements. Students had to judge how much each statement fitted them. There were several subscales grouped under four headings: self-regulation, learning activities, learning conceptions, and motivational orientations. A pretest–posttest design was used. It was not possible to employ a control group. Learning performance was registered by the transfer tests about "chances" and about "burns" and "hair," which were also used in earlier studies.

There was no overall effect of training on the two measures of learning performance (texts and problem solving), but there were significant aptitude treatment interactions. On both of the dependent variables the less successful students increased their scores, whereas the successful students remained on the same level or scored lower (see Table 7.2)

The differences between the first and the second delivery of the three subscales of the Homework Approach Questionnaire were significant for all students. They all ascored higher on action orientation and self-regulation and lower on mind orientation after training than before.

The answers to the Inventory of Learning Styles had also significantly been changed after the training. There were, after the training, changes in the scores of self-regulation, learning activities, learning conceptions,

TABLE 7.2. Means and standard deviations of the successful and the less successful students at the pretest and at the posttest.

		Pretest		Posttest	
Group	Test	*M*	*SD*	*M*	*SD*
Successful	Text	8.3	0.9	7.5	1.3
Less successful	Text	6.7	1.9	7.6	1.4
Successful	Problem solving	7.0	1.6	6.8	1.1
Less successful	Problem solving	4.5	1.7	5.8	2.0

and motivational orientation. Students scored higher on the scale of self-regulation and external regulation and lower on the scale "out of control." On all of the learning activities (relating, criticizing, analyzing, memorizing, and concretizing) the scores increased. As to the learning conceptions there was an increase in constructive conceptions and a decrease in reproductive conceptions. Of the five subscales of motivational orientation (exam-oriented, profession-oriented, test-oriented, person-oriented, and ambivalent), only the test orientation scores increased. In several cases the effects reported for the group as a whole were more outstanding for the less successful students than for the successful group.

Discussion

In our training research approach we tried to show that training should have an effect not only on learning performance but also on learning processes. Therefore, we designed the studies in such a way that changes in thinking aloud as a consequence of training could be shown. In only three or four out of the eight studies such results were found. It was only in training studies 1, 3, 4, and 8 that changes both in processing and in performance were obtained. In studies 2 and 6 neither processing nor performance effects were found. In study 5 only performance effects, but no processing differences, were found and in study 7 only some small processing differences appeared, with no performance differences. Changes in metacognitive knowledge were in all cases significant, however.

One may wonder what explains the success of some of the studies and the failure of others. Several possible explanations can be deduced from the differences between the studies: (1) the length of training; (2) the employment of computers or human tutors; (3) the characteristics of the student samples, differing according to age, intelligence, learning disabilities, and vocational or intellectual orientation; (4) embedding of the training in normal school activities; and (5) the adaptedness of the training to individual differences in processing. These five explanations will be discussed next.

The first explanation, the length of the training, cannot be a general factor of explanation. In the first study, consisting of only three training sessions, clear results were found. Furthermore, in the fourth study, having a much longer training duration, differences in performance showed up in early training sessions, leveling off later. Longer training periods (as in studies 5 and 6) were sometimes also ineffective. One thing was clear, however: short training did not work with learning-disabled children (study 2) and intensifying the training could have an effect, also with learning-disabled children (study 3). Our present hypothesis, then, is that training should be longer if students are younger, have learning disabilities, and are of lower intelligence.

The second explanation runs as follows: training is effective only when human tutors are involved; computer-aided training programs, using the same training materials as in human tutor experiments, failed. For this explanation there is some evidence in our experiments. The training studies employing human tutors (1, 2, 3, 4) were, with the exception of training study 2, effective, whereas the other four, employing computer-aided training, were less successful. Study 8, however, showed that computer-aided training can be successful as well. Furthermore, the study of Biemans, Van Deursen, and De Jong (1989) mentioned earlier (see the introduction of training study 8) also reached impressive effects of computer-aided training on performance and processing. The conclusion to be drawn is that computer-aided training worked only for older students and not for younger and learning-disabled students. What could cause the relative ineffectiveness of computer-aided training programs for younger and learning-disabled children? We favor the explanation that this has to do with motivation and affective processes. Changing your regulation processes and becoming an active learner is a difficult and stressful process, requiring a lot of endurance, belief, and self-confidence. We believe that our human tutors provided much affective help, which our computer programs did not give. Presumably they encouraged students to go on, they gave them somewhat more self-confidence, and they made clear that it was a worthwhile thing to do and to learn. Would it be possible to extend our computer learning aid with affective and motivational help? We think it possible, at least more than in our programs.

The third explanation concerns student characteristics. Some training studies may have failed to find effects because the students were too young, too severely learning disabled, or lacking in intelligence or reading ability. As stated earlier, we do not believe that this is true generally. We did manage to influence self-regulation processes and performance of learning-disabled and younger students. The younger they seem to be, the lower their intelligence and the more they suffer from learning disabilities; however, the more the human and affective-motivational aspects seem to be important.

The fourth explanation has to do with the embeddedness of the training in normal school life. Some of the training programs were rather isolated, others were explicitly integrated in meaningful activities of the students, like homework. Clearly, in our most effective training study (study 4), there was the best integration in real school life. But also in studies where there was a relatively isolated training situation, positive effects were reached (studies 1 and 8, for instance). Thus we think that although such embedding is a valuable aspect of training—probably especially when students are younger, of lower intelligence, and suffering from learning disabilities—it is not a necessary aspect under all circumstances.

The last explanation relates to the connection between the training design and the existing skills of self-regulation of the students. The ideal situation is to base a training on a sound diagnosis of the self-regulation skills and knowledge of the student. Collecting and analyzing thinking-aloud protocols is, however, a time-consuming activity. Therefore, it was often not possible to delay the training until the data were analyzed. Instead, the training was based on differences found in previous studies. This means that training was not closely adapted to the skills of the students. This might have been the case especially in the training studies 5 to 7, because the training was based on data collected with students of higher intelligence, whereas the students undergoing the training were of lower intelligence and sometimes were even having learning disabilities. These training programs might not have been suitable for that particular student sample. Reflecting on the results we think that if training lasts longer, incorporates more social interaction, emphasizes the affectional component of learning and is more adaptive to the students' regulation deficiencies, it is possible to teach learning disabled students to regulate their learning process and have more fun in learning.

References

Aarnoutse, C.A.J. (1985). *Programma Hoofdgedachten. Een serie uitgewerkte lessen voor het leren afleiden van de hoofdgedachten uit een informatieve tekst* [Program Main Idea. A series of lessons for learning to derive the Main Idea from an informative text]. Nijmegen: Berkhout.

Biemans, H.J.A., Van Deursen, P.F.A., & De Jong, F.P.C.M. (1989) De rol van de computer bij het leren leren [The role of the computer in learning to learn]. In P.R.J. Simons & J.G.G. Zuylen (Eds.), *Handboek huiswerkdidactiek en geïntegreerd studievaardigheidsonderwijs* (pp. 271–283). Heerlen: MesoConsult.

De Jong, F.P.C.M. (1987). Differences in the self-regulation processes between successful and less successful students and the prediction of learning performances in case of comprehension and learning of text. In P.R.J. Simons & G. Beukhof (Eds.), *Regulation of learning* (pp. 33–45). Den Haag: SVO-Selecta.

De Jong, F.P.C.M. (in press). *Werktitel: Zelf-diagnostisch leren* [Working title: Self-diagnostical learning]. Unpublished doctoral dissertation, Tilburg University.

De Jong, F.P.C.M. (1990). Executive controled, self-regulation trained in mathematics. In J.M. Pieters, K. Breuer, & P.R.J. Simons (Eds.), *Leaning environments. Contributions from Dutch and German research* (pp. 267–277). Berlin: Springer-Verlag.

De Jong, F.P.C.M., & Simons, P.R.J. (1988). Self-regulation in text processing. *European Journal of Psychology of Education*, *3*, 177–190.

De Jong, F.P.C.M., & Simons, P.R.J. (1990). Cognitive and Metacognitive Processes of self-regulated learning. In J.M. Pieters, P.R.J. Simons, & L. de

Leeuw. *Research on computer-based instruction*, (pp. 81–100). Amsterdam: Swets & Zeitlinger.

Kuhl, J. (1983). *Motivation, Konflikt und Handlungskontrolle*. Berlin: Springer.

Larsson, S. (1983). Paradoxes in teaching. *Instructional Science*, *12*, 355–365.

Lodewijks, J.G.L.C. (1981) *Leerstofsequenties: Van conceptueel netwerk naar cognitieve structuur* [Subject-matter-sequences: From conceptual network to cognitive structure]. Lisse: Swets & Zeitlinger.

Simons, P.R.J. (1984). Instructing with analogies. *Journal of Educational Psychology*, *76*, 513–527.

Simons, P.R.J. (1989). Modifying the regulation processes of learning: Two exploratory studies. *Canadian Journal of Educational Communication*, *18*, 29–48.

Simons, P.R.J., & Lodewijks, J.G.L.C. (1987). Regulatory cognitions during learning from text. In E. De Corte, H. Lodewijks, R. Parmentier, & P. Span (Eds.), *Learning and instruction: European research in an international context Vol. 1*, (pp. 357–368). Oxford: Leuven University Press and Pergamon Press.

Van der Sanden, J.M.M. (1986). *Het leren van technische vaardigheden* [Individual differences in learning technical skills]. Den Haag: SVO-Selecta.

Van der Sanden, J.M.M. (Red.) (1989). *Huiswerkbeleid* [Homework policy]. Lisse: Swets & Zeitlinger.

Vermunt, J.D.H.M. (1987). Regulation of learning to studying and learning, approches styles of adult students. In P.R.J. Simons & G. Beukhof (Eds.), *Regulation of learning* (pp. 15–32). Den Haag: SVO-Selecta.

Vermunt, J.D.H.M., Lodewijks, J.G.L.C., & Simons, P.R.J. (1986). Hardop-denken als onderzoeksmethods naar regulatieprocessen bij tekstbestudering [Thinking-aloud as a method for studying regulation processes during text processing]. *Tijdschrift voor Onderwijs Research*, *11*, 187–202.

Vermunt, J.D.H.M., & Van Rijswijk, F. (1988). Analysis and development of student's skill in self-regulated learning. *Higher Education*, *17*, 647–682.