SELF-REGULATION IN KNOWLEDGE ACQUISITION: A SELECTION OF DUTCH RESEARCH

Robert-Jan Simons & Jan D.H.M.Vermunt

Abstract

Self-regulation in knowledge acquisition is defined as the number and kinds of executive control processes students take over from teachers. A model of self-regulation in learning is derived from theories on metacognitive knowledge, executive control processes and teacher-regulations. Both control processes and their contents have a place in the model. Dutch research on self-regulation that can be fitted in the model is reviewed under two headings: individual differences and intervention.

Introduction

Self-regulation in learning appears under varied, but semi-related terminology in many publications. However, conceptual and methodological problems hampered the establishment of a common data base (Wang & Lindvall, 1984). Weinert (1982) in reviewing definitions of self-regulation in learning, did not succeed in finding a conceptual nucleus that might form the common meaning for the different terms and definitions.

In using one of the different words (self-direction, independent learning, autonomy, learner control, self-organized learning, self-efficacy, self-responsibility etc.) one often refers to a quality of the instructional process. Then, self-regulation is defined as, for instance, being allowed to influence essential decisions on what, when, how and with what purpose one learns (Weinert, 1982). Sometimes, self-regulation in learning refers to learning in an individual setting, without others being present (see Skager, 1979). Others, however, prefer to couple self-regulated learning to instructional settings in which cooperation with others is at least possible (de Brabander, 1985a; Wang & Lindvall, 1984). Some theorists see self-regulation in learning as a quality of learners. They refer to characteristics like

self-acceptance, planfulness, intrinsic motivation, internalized evaluation, openness to experience, flexibility and autonomy (Skager, 1979). Finally, especially in the Netherlands, self-regulation is placed in a development context (à la Vygotsky) and is seen as a goal of developmentally oriented education (van Parreren, 1982).

In our view self-regulation refers mainly to a quality of learning processes. Because of this, we prefer the word self-regulation above the other terms mentioned. We do not connect self-regulation to special instructional settings. Self-regulation can occur in private learning, under the direction of a teacher or even while listening to one. Self-regulation in our opinion, does not refer to the freedom teachers give to students to decide on their own, but to the freedom students take in making their decisions on learning. It has to do with how learning takes place instead of how instruction is given. It is a quality of learning processes that is both influenced by the instructional setting and the characteristics of the learner. One can learn in a non-self-regulatory way in rather free instructional contexts and in a self-regulatory way in restricted settings (we will come back to this later on). Our definition of self-regulation in knowledge acquisition is: "the number and kinds of executive control processes students take over from teachers" (see also Gagné & Briggs, 1979). Below, we will first discuss executive control processes in general. Then we will present a model of teacher-regulation of student-learning. Following that, we will derive a model of student-regulation by looking at the different ways students can take over executive control from teachers. Finally, we will discuss a selection of Dutch studies on student-regulation within the frame-work of this model.

Executive control processes

In an excellent analysis of definitions of the term meta-cognition, Lawson (1984) argued convincingly that the conceptual confusion in this field (see also Sternberg, 1985) should be resolved by introducing two different kinds of metacognition. Instead of pooling these two in one definition, as Flavell (1976) did, two separate

concepts are needed (see also Cavenaugh & Perlmutter, 1982). Flavell (1976) defined metacognition as "One's knowledge concerning one's own cognitive processes and products or anything related to them, e.g. the learning relevant properties of information or data. Metacognition refers among other things, to the active monitoring and consequent regulation and orchestration of these processes in relation to cognitive objects or data on which they bear, usually in the service of some concrete goal or objective" (p. 232).

Thus, both reflective awareness of cognitive processes (or metacognitive knowledge) and control of cognition (or executive control processes) are included in the definition (Lawson, 1984; see also Fischer & Mandl, 1983). Metacognitive knowledge, and executive control processes, according to Lawson differ from one another in terms of the extent to which each:

a. is conscious and therefore reportable;
b. is specific to a cognitive domain or expected to transfer across domains;
c. runs of automatically, or is a controlled effortful process.

By distinguishing these two kinds of metacognition one can resolve the inconsistency, also noted by Fischer and Mandl (1982) that Brown (1980) on the one hand restricted metacognition to conscious control processes, whereas on the other hand experts proved not to be aware of their control processes (for instance Simon & Simon, 1978).

Executive control refers to processes like planning, analysing, monitoring, evaluating and modifying (Brown, 1978; Lawson, 1984). They are seen to be higher-level processes because of their controlling role in cognition, and have a place in the top of many information-processing models. Simon (1979), for instance, defined them as follows: "the control structure governing the behaviour of thinking man in a given task is a strategy or program that marshals cognitive resources for performance of a task (p. 42)". "It is the marshalling, regulating function that is the defining feature of the executive processes" (Lawson, 1984, p. 91).

Lawson (1984) also theorized about the relations between metacognitive knowledge and executive control processes. In his view, metacognitive knowledge results from reflection on cognitive processes.
This reflection should be seen as an executive control process involving an examination of cognitive processes including analysis, evaluation, plans, monitoring and modification of cognition (see figure 1).

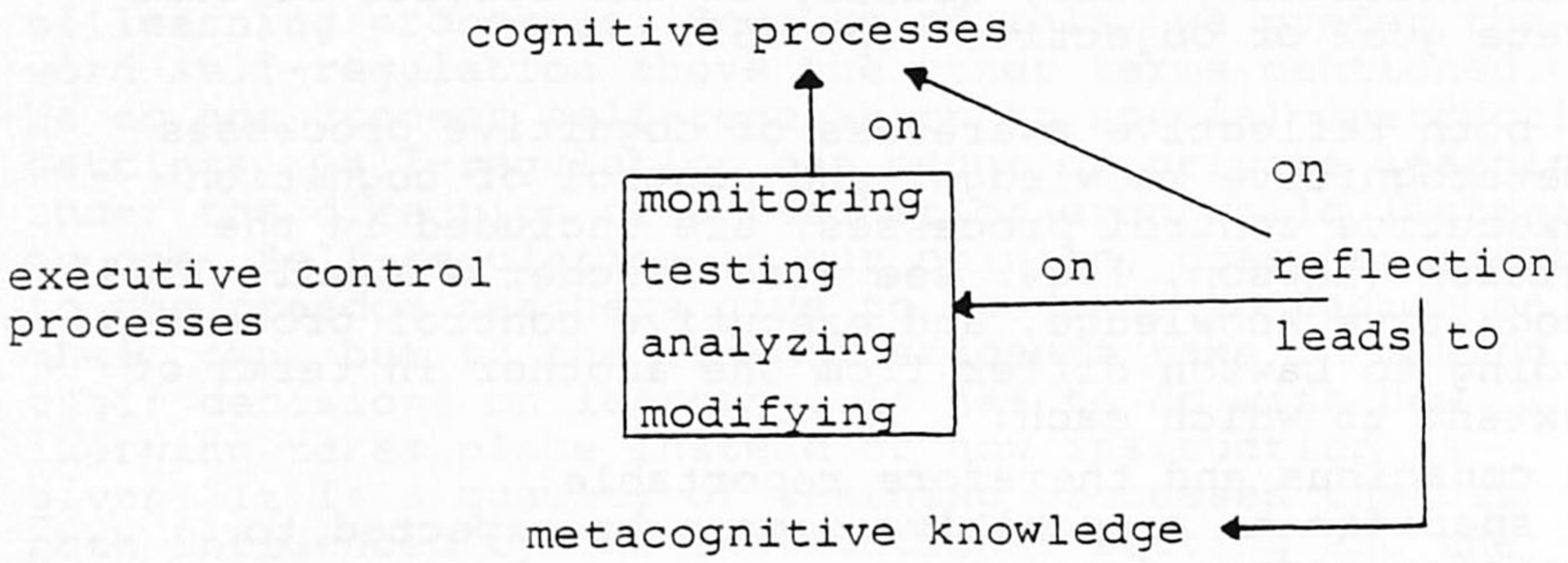

Figure 1: Metacognitive knowledge as the outcome of reflection

As Cavenaugh and Perlmutter (1982) suggest the nature of the executive operation may also depend on the individual's metacognitive knowledge, without there being a one to one correspondence (see figure 2).

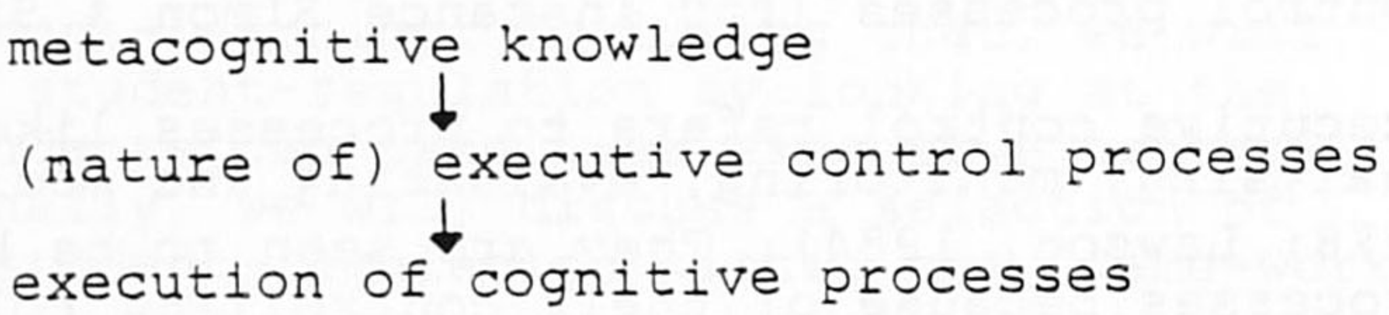

Figure 2: Executive control processes as influenced by metacognitive knowledge

To conclude this section, we will look at metacognitive knowledge and executive control processes from a different perspective, specifically from the "handelingstheorie" (activity-theory). Recently, van Parreren (1983) reformulated Galpèrin's (1969) theory on the learning of mental acts, by loosening the prescription that orientation (thinking beforehand

about the goals of an act, possible action-sequences, characteristics of the situation and analysis of the task) should always be complete. He now stated that orientation may sometimes be incomplete at the beginning of a learning-process if it only becomes as complete as possible at the end of it. Orientation should result in a plan of action. Orientation can in his view happen before learning, but also during learning and even afterwards. Orientation during learning shows up, in another publication (van Parreren, Assink & Borghouts-van Erp,1983), under the name of monitoring. Orientation afterwards is described as twofold: error-analysis and reflection. Error-analysis is thinking about possible causes of failures (in terms of action-sequences). Reflection is described as thinking about the reasons why the execution of a task was successful (e.g. discovering which intuitive rules led to your success). Reflection and error-analysis are seen to be important for the orientation on the next task. Figure 3 presents a summary.

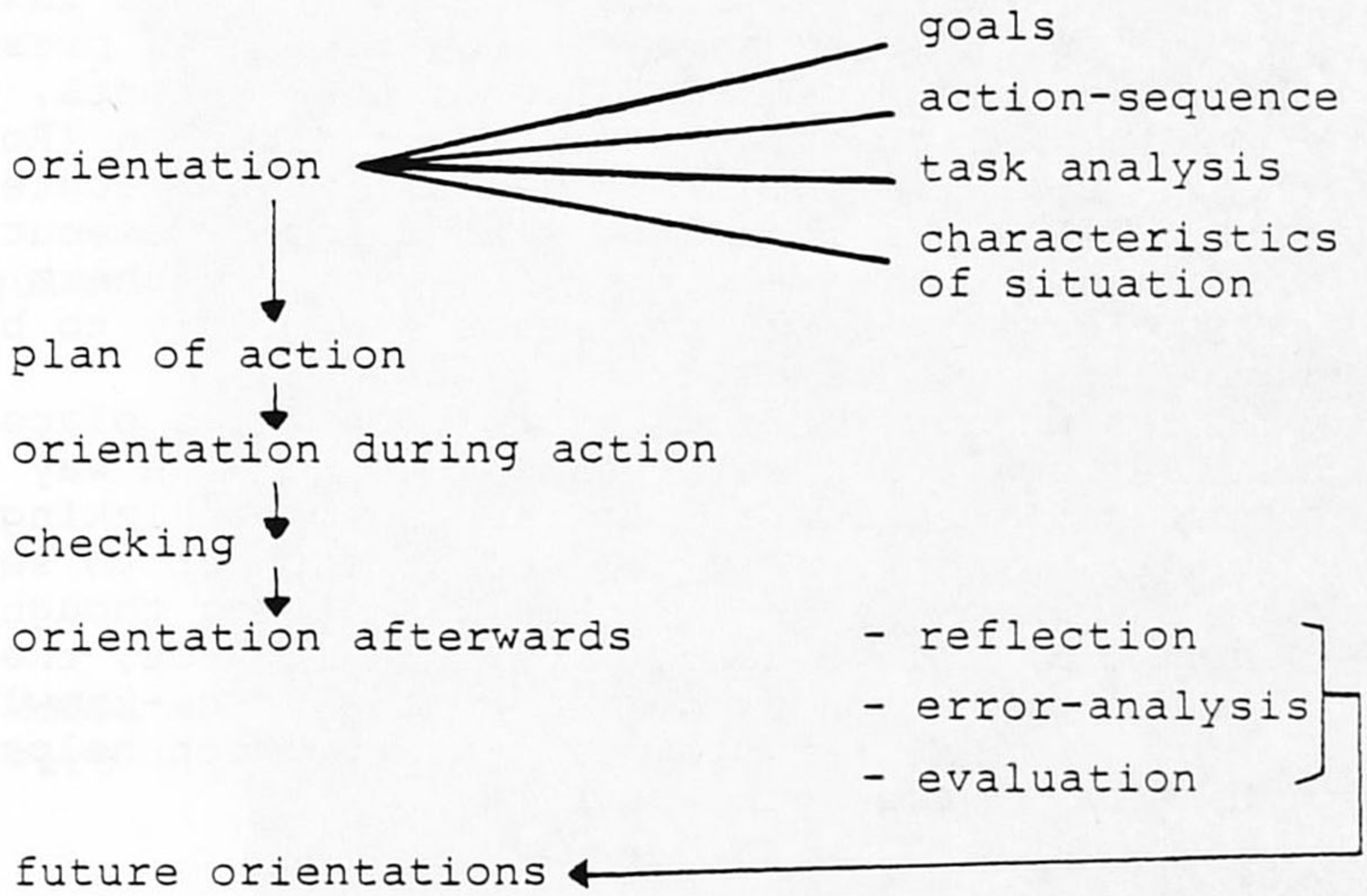

Figure 3: Executive control processes in activity theory

Although the concepts and ideas on regulation of the Russian activity theory and the American metacognitive approach are remarkably similar (see also van Parreren et al., 1983; de Klerk, 1983) we prefer Lawson's terminology and definitions because he differentiates between kinds of on-line processes and because he makes a distinction between reflective and automatic forms of executive processes. Finally, we think that activity theory places too much weight on processes happening before and after learning and underestimates the importance of on-line regulation (see Simons & Lodewijks, in press). Apart from these differences there is agreement on the central idea that reflection on the stream of cognitions and their regulation forms the major basis for metacognitive knowledge (or future orientations).

Teacher-regulation of student-learning

In teaching at least two different but interrelated kinds of regulatory processes must be postulated. Teachers have to regulate their own cognitive processes that are necessary for the operation of the instructional process. Thus, they have to regulate their presentation of information, their guiding of the students, their providing for practice and their evaluation (Rosenshine, 1983). Cognitive processes necessary to execute these functional tasks should be marshalled by executive processes. At the same time, however, teachers also have to regulate cognitive processes supposedly to be happening in students.
This can be done before instruction takes place by considering (orientation and planning) the way one can get students to learn, for instance by thinking about the best way to tune goals to students or to sequence subgoals (see figure 4a). Besides giving thoughts to the best method to teach a certain subject, the kinds of analogies to be used, and what advance-knowledge should be mobilized, is an activity which helps regulating learning beforehand.

Executive process	Definition
Orientation	Gathering information on possible ways to get students to learn
Planning	Deciding on the way one wants to architect the instructional process (open or closed planning) in order to get students to learn, and on goals

Figure 4a: Model of teacher-regulation of student-learning, Part I, before instruction.

Executive process	Definition
Monitoring	Judging whether students learned (observations)
Testing	Checking whether students learned (questioning, administering tests)
Re-orientation	Thinking about alternative ways to make it possible for students to reach the goals
Diagnosing	Finding possible causes for the failing learning of students
On-line regulation	Deciding on modifications in the planning of instruction in order to make it possible for students to reach the goals (selection of content, new analogy, other method)
Reflection	Thinking about the stream of cognitions and executive processes

Figure 4b: Model of teacher-regulation of student-learning, Part II, during instruction

Executive process: Definition

Many times, however, (see Halkes & Nijhof, 1982) teacher regulation of student-learning takes places during instruction instead of beforehand. We believe that there are six kinds of processes (see figure 4b) that roughly parallel the executive processes discussed before. Strictly speaking, however, these are no executive processes, because it is not the teachers' own cognitive processes which are marshalled but those of his or her students. Teachers may constantly judge the learning and understanding of students by interpreting their reactions to lectures, questions and assignments (monitoring) Secondly, teachers get information on the learning of students by testing their knowledge or understanding by administering tests, asking questions or giving assignments (testing). In the third place, teachers may, for instance in case of failing understanding, think of possible new ways to reach understanding after all, e.g. by asking questions like "will another repetition be helpful, do I know an adequate analogy, how did I do this last time" ((re-)orientation). Another process teachers may try is diagnosis: "why did learning fail?" "did the students pay attention?" etc. When this diagnosis or the reorientation leads to solutions, teachers may change their planning (if they had one) or start planning, for instance by introducing a new analogy, giving an extra assignment or repeating part of their lecture. This we call on-line regulation. Finally, teachers may reflect on the total process of actions they tried and their regulation of student-learning, for instance by thinking about the way they should regulate student-learning another time or about how they could get more information on student-conceptions (reflection).

After instruction teachers have to check whether student-learning was successful (evaluation), for instance by administering a summative test or by having students write an essay.

Thus far, we have looked at the way teachers regulate learning processes supposedly to be happening in students. Now we will be looking at the contents of this regulational processes. What kinds of processes do teachers regulate in students?

Figure 5 presents our model of tasks of teachers or events of instruction that intend to promote learning in students. It is based on the theories of Gagné and Briggs (1979) and Boekaerts (1982). Gagné and Briggs discern 9 types of events of instruction:

1. gaining attention
2. informing the learner of the objective
3. stimulating recall of prerequisite learnings
4. presenting the stimulus material
5. providing learning guidance
6. eliciting the performance
7. providing feedback about performance correctness
8. assessing the performance and
9. enhancing retention and transfer.

Two of these events, specifically providing learning guidance and assessing the performance should, in our opinion, be more properly placed among the categories of figure 4. The remaining ones should, in our opinion, be regrouped following the theory of Boekaerts (1982). She distinguished three kinds of learning processes that teachers have to stimulate in students: understanding, integration and problem-solving (application).

Understanding is defined as "making sense of" or "giving meaning". Integration is assimilating information into pre-existing knowledge structures. Application refers to the productive use of information in new situations or in problems. These three concepts may sometimes represent independent phases in a learning process, but most of the time they operate in conjunction. Boekaerts described how teachers may tune their teaching-behaviors to these three kinds of learning processes. Understanding can be promoted by analysing and interpreting information for students. Integration is to be enhanced by structuring information and designing memory-aids. Problem-solving can be aided by constructing an adequate problem-space, helping to find operations that lead to subgoals and helping to make decisions. In optimal instruction, didactic methods are adequately tuned to the three

kinds of learning goals. What we should learn from all of this, is that teachers have three important (functional) tasks: taking care of understanding, integration and problem-solving of students.

In our model (figure 5) three of the events of Gagné and Briggs have been replaced by two of Boekaerts' categories. Presenting the stimulus material became taking care of understanding and eliciting the performance, and enhancing retention and transfer became taking care of integration. New is Boekaerts' third teacher-task: taking care of problem-solving and application. This task is, so we presume, included in "enhancing retention and transfer". We agree with Boekaerts that it is important to distinguish integration and problem-solving, because they refer to different learning processes and because different teacher-behaviors are necessary to reach the two.

Finally, we think it necessary to add another teacher-task not present in the theories of Gagné and Briggs and Boekaerts: keeping students concentrated and motivated. The main reason for the addition of this task is that in our research on concerns of teachers on independence of students, concentration and motivation management proved to be their most important concerns.

1. gaining attention
2. informing the learner of the objective
3. stimulating recall of prerequisite learnings
4. taking care of understanding
5. taking care of integration
6. taking care of problem solving
7. providing feedback about the performance correctness
8. keeping students concentrated and motivated.

Figure 5: The contents of teacher-regulation

Self-regulation of learning

In the previous section we saw how teachers can exert control over the learning of their students. As our definition of self-regulation implies, students can also take over executive control processes from their teachers to regulate their own learning. This may be done in the classroom or outside of it when learning alone. When cognitive processes in learning are described as those

processes with which students try to reach their learning goals during a learning session, self-regulation means making use of a number of executive processes to control the course and results of these cognitive learning processes.

How can students do this for themselves? Previously we argued that they do this by taking over one or more of the tasks described before. Before actually starting to learn students may decide which way of learning is best suited to the learning task they are faced with. In order to find this, they can analyse characteristics of the learning task (e.g. level of difficulty, structure of content), of possible learning goals (including the teacher-defined ones), of one's own characteristics (e.g. relevant advance knowledge), and of the situation in general (e.g. available time, priorities in learning tasks). More-over, students can reflect on possible cognitive learning strategies or activities that may be used to perform the task. (see, for instance, Brown, Campione & Day, 1981). Having done this all, students can decide on a learning goal and a plan of action which are adapted to the mentioned variables (see figure 6a).

However important these orientation and planning processes before learning may be, many students seem to regulate their learning activities mainly during learning (for instance Simons & Lodewijks, in press).
When planning, one cannot foresee everything that is going to happen. Continuous attention and adaptation to changing circumstances is therefore necessary.
Taking over the executive control processes that play a major role in this phase of the learning process, means, in the case of monitoring, that students have to pay attention to and actively observe and interpret characteristics of the course and results of the learning activities they use (see figure 6b). Moreover, when this monitoring does not yield enough certainty about whether the learning (sub) goals are reached, students can check their understanding or retention by activities like trying to summarize in one's own words, to solve problems, to compare conclusions, to answer questions about the content, etc. (testing). When solving problems students can test their solutions by various checking operations. Such monitoring and testing activities may show that the learning activities that are used do not (soon enough) result in the desired outcomes. In this case a re-orientation may be necessary, in which students think about for instance alternative learning

activities about adjusting their goals (i.e. should I still strive for complete understanding?) Also students can diagnose the reasons for having difficulty with understanding. They may try to find out why the learning activities used failed to produce the desired outcomes, or why they succeeded. Was it because of the nature of the activities (e.g. memorizing did not result in understanding), the difficulty of the task, or situational demands (e.g. too little time)?
On the basis of such a re-orientation and diagnosis students may decide to change their activities or their goals, to select some learning contents for extra attention, or to persist in what they were doing (on-line-regulation). Reflection on the total learning process may result in knowledge and understanding about learning processes in general, and this knowledge can be used to regulate learning in future situations.

After learning students have to judge whether the final learning outcomes conform to the desired end-result they have in mind (evaluation). This can be done intuitively or more thoroughly, for instance by trying out exams of previous years.

As a result of reflection students may develop certain ideas about what learning strategies are most useful in various circumstances, and what factors must be considered in the choice of a learning activity. These insights and beliefs (metacognitive knowledge) can be used by students to regulate their actual learning and to interpret all kind of characteristics of the learning process, outcomes and situation.

Executive Process	Definition
Orientation	Preparation of learning activities via analysing the learning task and situation, possible goals, possible learning activities and individual characteristics as a learner.
Planning	Deciding on the way one is going to tackle the learning task.

Figure 6a : A model of self-regulation of student-learning. Part I. before learning.

Executive Process	Definition
Monitoring	Observing, interpreting characteristics of the course and outcomes of the learning process
Testing	Checking by means of explicit activities whether intermediate learning outcomes conform to the self-set goals
Re-Orientation	Re-analysing aspects of the learning task etc. in order to prepare a change of activity
Diagnosing	Analysing possible causes for the failure or success of the learning process
On-line regulation	Deciding on the speed of processing alternative learning activities or the object of them during the learning process
Reflection	Thinking about the stream of cognitions and executive processes

Figure 6b: A model of self-regulation of student-learning: Part II: during learning.

Executive process	Definition
Evaluation	Judging whether the final outcomes of learning conform to the end-goal aimed at

Figure 6c: A model of self-regulation of student-learning: Part III: after learning.

Thusfar, the "how" of student-regulation has been discussed. Now we will turn to the contents of the student-regulation by looking at the ways students can take over teacher-tasks

in this respect (see figure 7).
When students take over the first three teacher-tasks described before (gaining attention, informing students on goals and stimulating recall of prerequisite learnings) they have to orientate themselves and plan more thoroughly. They then have to think of important prior learnings themselves. They have to be aware of the possible goals to reach and they have to clearly plan the kinds of goals they think it worthwhile striving for. Furthermore, they have to be able to get themselves started, to motivate themselves and to believe that they are able to fulfill the task at hand (subjective competence).Instead of the teacher gaining their attention they now have to marshal their own attention and motivation.

When students take over the next three teacher-tasks (taking care of understanding, integration and problem-solving), they have to be able to perform the necessary cognitive strategies that lead to the three kinds of learning goals. More-over, they should also be ready to strive for the three kinds of goals. Finally, they should be able to regulate their learning in such a way that is adequately tuned to the kind of goal chosen.

- Getting started::attention and subjective competence, motivation and thinking of prior learning
- Taking care of understanding
- Taking care of integration
- Taking care of problem-solving
- Self-feedback
- Concentration

Figure 7: Contents of student-regulation

To reach understanding, students should make use of a variety of learning processes, which can be subsumed under the heading of 'deep approach' (Marton, 1983). Focusing on the intention of an author's or teacher's message, having the phenomenon dealt with in the test or lesson as the object of attention, relating the parts to each other and to the whole, checking the logic of an author's or teacher's line of argument, etc. are some subcategories of this deep approach. Janssen (1985) states that to reach full understanding students have to make use of analysing, synthesizing and structuring strategies. In the framework of Boekaerts' distinction,

this last strategy (structuring) can be seen as a way by which students may take care of integration of what they learned. Janssen (1985) describes structuring as a strategy by which students can integrate the knowledge and insights that are the result of both analysing and synthesizing strategies with each other and with already existing knowledge they have about the topic. He suggests that the making of schemes of the learning content may facilitate this structuring. Schmeck's (1983) 'elaborative processing' also fits Boekaerts (1982) description of integration. According to Schmeck components of this strategy involve the translation of information in one's own terminology and generating concrete examples from one's own experience.

In order to be able to apply learned information in new contexts to solve problems in which the newly learned information should be used, students should be ready to search for possible problems that might be solved with the learned information (creating a problem-space) and practical contexts in which it can be applied. Furthermore, students should be able to regulate their own problem-solving behavior, like designing a sequence of subgoals and subproblems.

The seventh and eighth teacher-tasks (providing feedback and keeping students motivated and concentrated), when transferred to student self-regulation, imply that attributions and motivations form important aspects of self-regulation. Students now have to keep themselves task-directed and motivated and they have to provide positive self-feedback, through monitoring and testing, in such a way that they do not give up too easily.

To conclude this section, we think that there are at least three possible reasons why self-regulated learning may not be succesful.

1. the cognitive strategies necessary for understanding, integration and application are not mastered by the students: they cannot use them (mediation-deficiency).
2. the cognitive strategies are mastered, but the student does not use them at the right time and place, does not check whether they are used effectively etc. (regulation problems or production-deficiency).
3. a student does not reflect on learning in general and his or her way of learning in particular. His or her conception of learning is restricted to a few reproductive activities and there is an ignorance of situational

demands (problems connected to metacognitive knowledge or conceptions of learning, see for instance Thomas & Harri - Augstein, 1985).

Teacher-regulation versus student-regulation

We defined student-regulation of learning as the number and kinds of executive control processes students take over from teachers. In the past sections we tried to describe these executive control processes and their contents in some detail. In this section we will consider relations between teacher- and student-regulation and their effects on performance.

In our department several studies were made of the influence of partial student-regulation on performance.
For instance, Lodewijks (1981) compared a student-regulated sequence with a condition that was teacher-regulated (fixed). The fixed sequence proved to lead to better results in weaker performers, whereas the student-regulated sequence was better for the better-performing ones. A similar study was done by van der Sanden and Schouten(1986) with a practical construction task (designing a soldering-bolt-holder). Their results were, in essence, the same as those of Lodewijks. Extensive hints on the best plan of action were good for the weak performers, but hampered the performance of the better performing student.
Finally, Simons (1980) showed that supply of concrete analogies by the teacher or text improved the learning of some of the students while it hampered that of others.

These three results were interpreted as evidence for the existence of a tension between teacher- and student-regulation. When (better) students are able to do their own regulation (as to sequence, action-plan, analogies), teacher-regulation hinders optimal performance. On the other hand when teachers fail to regulate the learning of the weak students, their performance gets still worse.
An obvious implication of these studies would seem to be that differentiation is necessary: give better students more freedom to learn and regulate the learning of the weaker-students. This, however, poses some serious problems. For one thing, this is hardly a practical advice, for another there are undesirable long-term consequences. Don't we want all our students to become self-regulated learners? In summary, we think that there are four kinds of tension between teacher- and student-regulation.

a. when teachers regulate a lot, students cannot regulate much themselves;
b. when teachers regulate a lot, students will not learn how to regulate their own learning;
c. when students are not able to regulate their own learning, teachers are forced to do it for them;
d. because teachers cannot manage differentiated instruction, they choose to regulate the learning of all students in the same way.

This vicious circle leads, in our opinion, to an absence of self-regulatory skills in most of the students.

Apart from the described tensions between teacher and student-regulation, there is also an interdependence between the two. This also showed up in research done in our department. For instance, in a study reported by Simons, Lodewijks and de Klerk (1984) students were asked to study a text with a certain goal in mind. Some were asked to learn the facts and details, others were asked to understand the main points. Although the instructions were quite clear and provided extensive examples, only part of the students adopted the planned goal, the others stuck with the kinds of goals they were used to. Thus students have to agree with the goals set; teachers cannot force students to adopt the goals they like them to strive for.

Another example of interdependence of teacher- and student-regulation showed up as a side-effect in a study reported in Simons (1983). Students were asked to study a very complicated and long piece of text on science. The study was on patterns of repetition and drill. Therefore, a relatively long period of time was given. However, the study failed completely. After twenty minutes all students claimed in earnest to have gained complete understanding of the contents of the text. They were used to reading texts (normally one page, now twenty pages) only once. Later test-results showed that all students learned practically nothing. Thus, one cannot predetermine time-planning by students, because they decide for themselves whether they are ready or not.

A last example of interdependence of teacher- and student-regulation goes the other way around. In the two examples mentioned teacher-regulation failed because of student-

regulation. In the next example student-regulation is dependent on teacher-regulation. Van Rossum and Schenk (1984) found that many students complain that they prefer a meaning-oriented deep-level strategy, but that the kinds of questions (multiple-choice) teachers pose force them to adopt fact-oriented surface level strategies. Thus, teacher-testing routines determine the quality of student learning-strategies.

Research on self-regulation: individual differences

In this section we will discuss individual differences in self-regulation, fitting in the presented model in figure 6. For all of the categories some individual differences will be illustrated by selected Dutch research.

a. Orientation

In order to be able to orientate oneself on a learning-task, metacognitive knowledge of different learning goals, task-features, planning, cognitive strategies and relations between goals and strategies might be a necessary but not sufficient condition.

Students of secondary schools differed in their (meta-cognitive) knowledge of different learning goals and the way one can adopt learning strategies to different goals (as understanding versus remembering) and task-demands (as the kinds of questions the teacher will think important (Place-van Tongerloo, 1982)).
Many of them had only superficial notions of these things (o.c.). But also many students in higher education proved to have rather restricted and simple conceptions of what learning is or can be (van Rossum & Schenk, 1984).

Another individual difference pertaining to orientation is the extent to which students orientate themselves to learning tasks. Van der Sanden and van Eck (1985), for instance, showed that some students did not orientate themselves to a practical construction-task, showing a trial and error approach, whereas others started with a relatively extensive period of orientation.
Place-van Tongerloo (1985) and Breyman, de Jong and Vermijs (1984) also described secondary school students who did not orientate themselves on their home work at all (for instance they did not look in their school diaries, or they did not read the introduction to an assignment)

whereas others did. Furthermore, Vermunt (1984a) using thinking-aloud protocols, discovered that the extent of orientation should be tuned toward the kind of learning task: good students orientated themselves extensively on a problem-solving task, but not on a routine-task like learning a vocabulary.

Finally, van Parreren (1982) reports that in many studies on the learning of mental acts it was shown that students of different ages orientate themselves insufficiently and inadequately.

A third individual difference in orientation concerns its quality. In many studies on problem-solving it was shown that experts not only orientated themselves more, but above all in a different way than novices (Elshout, 1984). Experts, for instance, tended to orient themselves thoroughly at the beginning of the solution process, whereas novices tended to start right away and needed a lot of re-orientations during the solution process, jumping from one blockade to the next one. Span and Overtoom-Corsmit (in press) showed that gifted students solving mathematical problems operated more like experts and average students more like novices.

Finally, the contents of the orientations may differ. Some students emphasize their past failures and success in their orientation (ego-orientation), while others concentrate on the goals and strategies to reach them (action-orientation)(Bierkens-van de Watering, 1984; Eikelkamp & Senden, 1985; compare also Kuhl, 1983).

b. <u>Planning</u>

As noted before, planning highly correlates with orientation. Orientation is considering all kinds of possibilities as to for instance goals, strategies and their relations, and planning refers to the decisions made concerning these aspects. Mostly therefore, in research orientation and planning are difficult to distinguish empirically. Therefore, what we stated above on the insufficiency and inadequacy of many orientations is generalizable to planning. In general, many (especially younger) students hardly seem to plan their learning. This counts both for (micro)planning of a task (strategies, time-allotment) as for planning over different tasks (sequence, time).

Individual differences as to planning may have to do with many preparatory activities of students, like choosing goals, designing a sequence of subgoals, choosing learning activities and strategies, making a time-schedule, tuning learning activities to goals, but also with how to monitor and test learning, what to do in case of problems, etc. Some of these have been studied empirically in The Netherlands. Individual difference variables in higher education that have been investigated by several researchers are time-planning and planful studying. Some of them found no correlations between these variables and performance (Buis, 1979; Crombag, Gaff & Chang, 1975). others however, did find significant correlations (Smit & van Os, 1985; Lacante, 1983). Breyman, de Jong and Vermijs (1984) studying students from secondary education discovered very simple time-planning strategies. Students learning under time-restriction, simply skipped the learning tasks they did not like or did not feel confident about and saved all their energy for the nice and simple tasks.

Another variable studied is planning of learning activities. Can students adjust their way of learning to the goals that are imposed or the kinds of questions that may be expected (facts versus insight; open versus closed questions)? Simons, de Klerk and Lodewijks (1984) describe an experimental study which showed that only few students in a secondary school adjusted their way of learning to whether they learned for facts or for insight. More-over, the ones that did adjust their way learning, did so by adding an extra rehearsal of facts.

Contradictory data have been reported on the question whether students are able and ready to adjust their way of learning to the form of questions posed (open or multiple choice). Although many students claim to learn in a different way with different testing-expectations, their actual adjustments seem to be rather minimal (see Meerum-Terwogt, 1979; d'Ydewalle, Swerts & de Corte, 1983).

A last example of an individual difference in planning relevant to self-regulation, refers to choosing and clearing learning goals and their personal relevance. In a long-lasting research project de Brabander (1985a, 1985b) studied this aspect of planning.
He claims that this is the core of self-responsible learning which, however, is absent in most students of

secondary schools. Students acted on the basis of their interpretations of expectations on the side of the teacher, even though he did not verbalize these explicitly. Traditional communication-patterns in schools, according to de Brabander, restrain students from evaluating learning goals in the light of their personal needs. Therefore, they do not think about learning goals themselves. They just let the teacher decide on the goals and comply.

c. Monitoring

During learning self-regulation as to monitoring means being able to pay attention to and actively interpret and observe one's own state of understanding, integration and problem-solving. Moreover one has to monitor the execution of the plan of action (e.g. time). Finally, states of the mind concerning subjective competence, liking of the task (etc.) can also be monitored. Individual differences as to monitoring that have been studied empirically have to do with preferences for the object of monitoring: some students mainly seem to be monitoring their own (emotional) states of mind (compare Kuhls' (1983) mind-orientation) and others mainly monitor the execution of the action-plan (action-orientation). Eikelkamp and Senden (1985) were able to measure these kind of differences by way of thinking-aloud methods. They distinguished between four kinds of verbalisations: refering to cognitive processes, regulating processes, mind-orientations and irrelevant processes. Students from a school of special education differed in the ratio between relevant and irrelevant processes. This ratio predicted performance reasonably well. Furthermore students differed in the number of mind-oriented monitoring-processes. Two kinds of these were found: fixation on subjective competence (Oh I don't understand a word of it) and fixation on an opinion about the task (Oh I hate these calculations).

The tendency to fixate one's monitoring on failures and successes was also measured by way of a questionnaire (Bierkens-van de Watering, 1984). Some evidence for construct-validity was reported.

Another aspect of monitoring that has been found empirically by Wouters and de Jong (1982) concerns noticing failure to understand. In thinking-aloud

protocols of psychology students studying an instruction-text this kind of monitoring showed up.

d. Testing

One aspect of testing during learning that might be important, is the quantity of it. Vermunt (1984a) showed that in learning a vocabulary the number of times a subject tests himself differentiates between well- and weak-performing subjects. In text-learning however, it was not the number of testings which proved to be important, but their quality. Better performing subjects tested their text-learning in a different way than weak performers (see Simons & Lodewijks, in press).

Many researchers in Holland, inspired by the theory of the Russian theorist Galpèrin (e.g. 1969), believe that self-checking and self-testing during learning form the most important aspects of learning. Moreover, many of them believe and some of them showed empirically that students have problems in self-testing, for instance as to spelling (Assink, 1983), note-taking (Dudink, 1985), problem-solving (de Jong & Ferguson-Hessler, 1984) and psychomotor-learning (Pijning, 1985).

e. (Re-)orientation

When enduring learning problems occur (like a failure to understand, or a failing plan), re-orientation may be necessary. Re-orientation also will occur when students fail to orientate themselves thoroughly before the actual learning-phase starts, as many students seem to do (van Parreren, 1984). Jansweier, Elshout & Wielinga (1985) showed that beginning problem-solvers go from one sub-problem to another, re-orienting continuously, whereas experts orientate themselves more extensively at the beginning. Breyman et al. (1984), in studying students from secondary schools doing their homework, also found that a minimal amount of orientation before learning and many re-orientations during learning occured. Finally, also Vermunt (1984a),in his thinking-aloud protocols of students performing homework-tasks, found more re-orientations than orientation before learning. The amount of orientation and re-orientation proved to differentiate good students from weak ones when a science-problem had to be solved.

f. Diagnosing

When problems occur during learning students might look for the causes that lead to them. Students may ask questions like "Why don't I understand this part of the text?" or "What went wrong in the problem-solving process?". One individual difference refers to the willingness to search for causes and reasons of failures. Blaakman and Vermunt (1983) reported that many students (secondary school), when confronted with problems just stopped and quit instead of re-orienting diagnosing and looking for new possibilities (on-line regulation). Pijning (1985) investigating psychomotor learning distinguished between an error-analysis-strategy (diagnosing why one failed) and a performance oriented strategy (concentration on the goals to be reached without attention for the cause of failures).

g. On-line regulation

Hettema (1979) distinguished six repair-mechanisms: reflection, exploration, uncoupling, substitution, persistence and redirection. The first two of these appear in our scheme in other sections (reflection and re-orientation respectively). The remaining ones belong to our category of on-line-regulation. Uncoupling is choosing a new strategy. Substitution is changing the way a chosen strategy is executed. Redirection is changing the goals (mostly chosing lower level goals) and persistence is trying again in the same way. Breyman et al. (1984) were able to find instances of all four of these repair-mechanisms in their secondary school students, especially when they had to study under strict time-limitations.

A group of researchers under direction of Riksen-Walraven and van Lieshout (1985) developed measures that correspond to persistence and redirection: ego-resiliency and ego-control (cf Block & Block, 1980). They found evidence for the validity of these measures in that they correlated quite well with school performance and not with intelligence (Mey, Siebenheller, ten Brink, Koot & Janssen, 1985).

Another probably important aspect of on-line regulation is seeking for help. At the Free University of Amsterdam de Leeuw and colleages are investigating the number and quality of help-seeking questions of students learning from a computer (de Leeuw, in press).

h. Reflection

As has been stated in a previous section, reflection on cognitive processes and on executive processes is considered very important by both theorists from the meta-cognitive tradition and from the Galpèrin tradition (Lawson, 1984; Zak, 1980). Two other groups of foreign theorists (in Sweden Säljö (1979), in England Thomas & Harri-Augstein (1985) also consider reflection to be very important. In The Netherlands Vedder (1985a, 1985b) studied reflection abilities of children from elementary schools. He devised a reflection ability scale and showed that reflection to some extent could be promoted by cooperative learning. Van Dijk (1985) however, showed that meta-cognitive and strategic considerations occurred only rarely and came mostly from the same group members. Vermunt (1985) devised a learning style instrument to be used in the Open University that has a reflection on learning scale as one of its subscales.

i. Evaluation

Many of the things said about testing, monitoring and diagnosing during learning, could also be transferred to evaluation processes taking place after learning. Evaluation can refer to the contents of learning ("Am I ready to be tested?", "Did I learn enough?" and to the process of learning ("Where and why did I go wrong", errror-analysis; "Why did I succeed?", reflection). Span and Overtoom-Corsmit (in press) found that gifted students tended to evaluate and control their problem-solving attempts more often than average students.

j. The contents of selfregulation in learning

According to our scheme of tasks students can take over from teachers, six kinds of student activities and processes were distinguished above. One of these was called "getting started". Under this heading the marshalling of attention, motivation and subjective competence was grouped. Much research has been done in Holland on these topics, especially as to motivation (see for instance Boekaerts & van Lieshout, 1982). Subjective competence, a subject's estimation of his own competence to master a certain task, and getting and remaining concentrated have been studied by

van Erck and Wiegers (1984), de Jong and Annink (1985) and Dawood, Detiger-Kort and de Zwart (1984). They developed and validated instruments that can measure individual differences as to these two aspects. Concentration was also investigated by de Leeuw, Fey, van der Zee (in press). In a nation-wide survey an alarming increase in problems as to concentration ability and impulsivity was found.

Too much research to be possibly summarized here has also been done on diverse cognitive strategies that lead to understanding, integration and problem-solving. These refer for instance to individual differences in deep versus surface strategies (van Rossum & Schenk, 1984), elaborative versus deep processing (Vermunt, 1985; Janssen, 1985), text-processing strategies (for instance van Hout-Wolters, 1982 ; Wouters & de Jong, 1982) and problem-solving (e.g. Elshout, 1984). Finally, no research has been performed, to our knowledge, on self-feedback. Concentration and motivation have already been mentioned previously.

Improving self-regulation: some Dutch examples

As was illustrated before, one cannot assume that by observing how the teacher regulated their learning, students automatically become better at regulating their own learning. In this section some examples will be discussed of Dutch intervention programs directly aimed at improving self-regulation in students.

Intervention of this kind can be aimed either at making students more aware of their own and alternative learning processes, at improving the executive control-processes students use when performing a learning task, or at improving cognitive skills relevant in self-regulation (Palincsar & Brown, 1984).

Examples of the first kind are the investigation of van Someren and Elshout (1985) and Elshout-Mohr (1985). The first researchers tried to induce self-reflection through having subjects formulate a reason for every move when learning to play chess. After intervention the experimental group outperformed the control group on a new problem. Elshout-Mohr (1985) developed an intervention program for university students with which she tries to change the 'belief system' of these students. Students

have all kinds of beliefs and misbeliefs about learning and studying and how to manage when performing learning tasks of a particular kind (meta-cognitive knowledge). Some of these can cause problems, and through a 'debugging' procedure Elshout-Mohr tries to stimulate students to reflect on their beliefs. As yet there are no data about the results of this program.

Intervention can also be aimed at improving the executive processes students use. De Brabander (1985) developed a guidance program aimed at improving the strategic aspects such as the preparation, guidance and evaluation of learning activities. Students were especially trained (one hour a week, during one year) in choosing and evaluating learning goals. The results of the program indicated a growing independence of the students, but failed to show an increase in the capacity for reflection on learning needs.

Mettes and Pilot (1980) developed a system of heuristics in order to improve the learning of systematic problem-solving of first year thermodynamic students. A thorough orientation, resulting in a plan for the solution process and checking and evaluation processes were the nucleus of this program. This system was built in into experimental courses. It proved to be successful in thattrained students performed significantly better on examinations and some other measures. De Jong and Ferguson-Hessler (1984), however, were less successful with a similar approach and did not manage to improve either problem solving strategies or performance.

There were also some investigations on the effects of training programs that tried to improve skills that are expected to be important in independent learning.

Kok, Boonman and Beukhof (1980) defined, on the basis of a theoretical model, an optimal strategy for text processing. This strategy was then translated into a heuristical procedure, which was meant to regulate the text processing of primary school pupils. In a training study the effects of this procedure were examined.

Contrary to the expectations trained students scored significantly lower on a posttest on retention of information than the control group did. As possible reasons for this result the authors mention a too short training time and interference problems.

Dudink (1985) showed in six studies that it is possible to teach children from elementary school (fourth grade) to take better notes. He attributes the success of the course to the fact that the children learned to check their notes during and after learning.
Bol (1982) and Aarnoutse (1982) both developed training-programs that teach comprehension-skills like identifying main points and analyzing a text.
Both programs succeeded in improving comprehension-skills.
As a final example in this category research on schematizing should be mentioned.
Breuker (1980) and others developed a course that teaches students of higher education to make visual text-schemes and to use these in learning.

Finally, we will describe two training studies that combined awareness-training and training in executive control processes.

Vermunt (1984 b) trained second year secondary school children in self-regulating learning activities when learning texts. In the training attention was devoted to making students more aware of differences in learning approaches. Besides a set of heuristic questions was developed that students could ask themselves before, during and after learning. The answers to these questions would yield information on the best suited next steps in the learning process (on-line regulation). Several possibilities were suggested on how to answer these questions. Finally, some opportunity for practice with these heuristics was given. On a post-test the experimental group increased, among other processes, their testing for understanding when studying a text, an increase not showing up in the control group. Also an increase in performance on a multiple-choice test for understanding was observed in the experimental group, and not in the control group (see Simons & Lodewijks, in press).

Eijkelkamp and Senden (1985) in a similar training experiment with students with concentration problems tried to combine awareness-training with a self-instruction technique. This consisted of a heuristic that directs attention to action- or process-oriented executive control and diminishes attention to mind-oriented and irrelevant processes. They, however, failed to find a general effect of training, though some of the students seemed to have learned to concentrate better.

Conclusion

In this paper we tried to define selfregulation in learning in terms of the metacognitive knowledge and executive control processes one would need to have. These were derived from theories on teacher-functions and teacher-regulation of learning. We think that this might be the beginning of a theory on selfregulation to be tested in further research-projects. A review of Dutch research fitting in the theory revealed some interesting individual differences. Further research on the nature of these differences and their relations to performance and other variables is, however, necessary. When more is known about individual differences, training of selfregulation might become more successful. As to training, we agree with Palincsar and Brown (1984) that good training programs unite awareness-training, skilltraining and executive control-training. Finally, we would like to ask attention for skills and executive control processes that operate during learning (self-checking, revision-mechanisms, reflection) instead of attention for skills and executive processes operation before and after learning takes places (questions, aims, summaries). In our opinion future training programs should focus on these on-line processes and skills.

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