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Review

How can primary school students learn self-regulated learning strategies most effectively? A meta-analysis on self-regulation training programmes

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ABSTRACT

Recently, research has increasingly focused on fostering self-regulated learning amongst young children. To consider this trend, this article presents the results of a differentiated meta-analysis of 48 treatment comparisons resulting from 30 articles on enhancing self-regulated learning amongst primary school students. Based on recent models of self-regulated learning, which consider motivational, as well as cognitive, and metacognitive aspects [Boekaerts, M. (1999). Self-regulated learning: Where we are today. *International Journal of Educational research, 31(6)*, 445–457], the effects of self-regulated learning on academic achievement, on cognitive and metacognitive strategy application, as well as on motivation were analyzed. As the results show, self-regulated learning training programmes proved to be effective, even at primary school level. Subsequent analysis tested for the effects of several moderator variables, which consisted of study features and training characteristics. Regarding factors that concern the content of the treatment, the impact of the theoretical background that underlies the intervention was tested, as well as the type of cognitive, metacognitive, or motivational strategy which were instructed, and if group work was used as instruction method. Training context related factors, which were included in the analyses consisted of students' grade level, the length of the training, if teachers or researchers directed the intervention, as well as the school subject in which context the training took place. Following the results of these analyses, a list with the most effective training characteristics was provided.

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1. Introduction

Dramatic changes in the availability of information, resulting from an exponentially growing amount of knowledge, as well as the rapid development of technology, have necessitated new approaches for information handling and treatment. New requirements concerning key competences of learners from this knowledge-based society have resulted in a large amount of research on how to make learning more efficient. Self-regulated learning is a construct that has developed during the last 30 years in order to meet these demands (Winne, 2005). Self-regulated learners dispose of the skills to learn effectively both in school and later in life. As such, self-regulated learning has been highly praised as *the* key competence to initiate and maintain lifelong learning (see e.g., EU Council, 2002). Its introduction has gone along with a paradigm shift in research on learning and instruction, leading to a focus on the learner as an active participant in the learning process. The concept of self-regulated learning has been brought up as a synthesis between research on how *learning* functions – focusing on the learner's cognitive and motivational processes (e.g., Boekaerts, 1999; Pintrich, 1999) – and research on how *instruction* functions—focusing on the interaction between learner and instructor in a social environment (e.g., Schunk, 2001; Zimmerman, 1989). As a result, various approaches of providing learners with the skills of self-regulation have emerged.

1.1. Why is it worthwhile to implement self-regulated learning training programmes in classrooms?

Due to a multitude of empirical evidence, there is now a consensus on the effectiveness of self-regulated learning on academic achievement (e.g., Chung, 2000; Paris & Paris, 2001; Winne, 1995; Zimmerman, 1990; Zimmerman & Bandura, 1994; Zimmerman & Martinez-Pons, 1988), as well as on learning motivation (Pintrich, 1999). Furthermore, self-regulated learning is a key competence for lifelong learning (European Framework of Life-long Learning, EU Council, 2002). Considering these three areas where students can benefit from self-regulated learning – academic performance, motivation to learn, and learning strategies – the value of self-regulated learning training programmes becomes clear. Providing students with knowledge and skills about how to self-regulate their learning helps them to self-initiate motivational, behavioural, and metacognitive activities in order to control their learning (Zimmerman, 1998). Moreover, research on instruction of self-regulated learning has revealed the gain of implementing these training programmes directly in classrooms: first, strategy instruction should be context-related which is easier to attain when embedding it in regular instruction. Empirical studies found that training programmes are more efficient if students are learning domain-specific content and, in addition, strategies to handle this content competently so that both can be related to each other (e.g., Perels, Guertler, & Schmitz, 2005). Second, training programmes should also create learning environments that are conducive to self-regulated learning, so that students are provided with opportunities to apply and practice the newly acquired strategies (Van Hout-Wolters, Simons, & Volet, 2002). Third, in order to enhance transfer of self-regulated learning to other areas even contextualized forms of strategy instruction need to address the issue of transfer directly (Fuchs et al., 2003a, 2003b).

Considering this highly elaborated and detailed amount of research, one could expect a well-elaborated application of this research knowledge in the classroom. However, despite numerous intervention studies to teach students strategies for self-regulated learning conducted in this field, a composition of the optimal characteristics of such interventions is difficult to find. Training programmes appear to be rather heterogeneous, depending on the various underlying models of the construct of self-regulated learning.

1.2. Why conducting a meta-analysis on self-regulated learning training programmes?

Research on self-regulated learning often comes from different areas, focusing on various aspects of learning. This is leading to a large amount of training studies presenting a large variation in theoretical assumptions and study designs, reaching for different goals. In order to get an overview of which kind of training programme that aimed at fostering self-regulated learning amongst students worked most effectively, it would be desirable to compare systematically the differing types of intervention. Despite the great amount of research on fostering self-regulated learning in school settings, there is a lack of such a methodical comparison of recent empirical work. A meta-analysis conducted with studies published between 1982 and 1992 by Hattie, Biggs, and Purdie (1996) compared 51 interventions that aimed to enhance students' learning by improving the use of study skills. This analysis included programmes, which focused on task-related skills, as well as on self-management skills and motivational and affective elements. The results indicated that interventions were most effective when being situated in a context, and fostering a high amount of student activity and metacognitive awareness. Nevertheless, the studies included in that review do not reflect the latest state in the field any longer. Since new models of self-regulated learning evolved during the last decades, influencing the intervention in this field (Boekaerts & Corno, 2005), a detailed view on relevant studies conducted in the last years seems to be necessary. In addition, most of the studies included in Hattie et al.'s meta-analysis were conducted with secondary school or university students. However, research of the last decade has shown the impact of these kinds of interventions for young students. This meta-analysis therefore focuses on the effectiveness of training programmes for primary school children.

1.3. Self-regulated learning amongst young students

Most of the research on self-regulated learning in school settings has been conducted with older students, in the upper-elementary grades through college (Perry, Phillips, & Dowler, 2004). According to the suggestions resulting from most of the research from the 1980s and 1990s, children at the elementary grades and younger should have difficulties with applying cognitive and metacognitive strategies (Paris & Newman, 1990; Zimmerman, 1990). Studies on the development of metacognitive knowledge and self-regulated learning reported a major shift between kindergarten age and grade six. However, even if self-regulated learning increases during the elementary school years and can be found effective only in the end of elementary school age, empirical evidence illustrates self-regulation of learning already in preschool children (Schneider & Lockl, 2002). It therefore makes sense to investigate the effects of training self-regulated learning during development. Research over the last 10 years has given empirical support to the presumption that young children can and do engage in activities to self-regulate their learning (e.g., Biemiller, Shany, Inglis, & Meichenbaum, 1998; Bronson, 2000; Perry et al., 2004; Perry, VandeKamp, Mercer, & Nordby, 2002; Whitebread, 1999). Hattie et al. (1996) even found that the youngest children benefit the most from training. The major advantage of training children how to self-regulate their learning in the beginning of their schooling is that during these first crucial years, students set up learning and self-efficacy attitudes (Whitebread, 2000) which are easier to change than when students have already developed disadvantageous learning styles and learning behaviour (see Hattie et al., 1996).

1.4. Models of self-regulated learning

Considering the evolution of the conceptual models of self-regulated learning over the last decades, there is a change in focusing on different aspects of learning. Paris and Paris (2001) describe the historical trends in research on self-regulated learning from the 1970s, investigating strategy use mostly in the cognitive area, and in the 1980s, when researchers started the experimental implementation of differing strategy conditions, including more and more metacognitive aspects of learning. In the 1990s, research finally highlighted strategy intervention in the classroom (Paris & Paris, 2001). Recent models for self-regulated learning have increasingly emphasized the impact of motivational and volitional components on learning (Boekaerts & Corno, 2005). Nevertheless, even when restricting the focus on the latest models, different concepts and definitions of self-regulated learning seem to emerge. Puustinen and Pulkkinen (2001) confronted the latest five models on self-regulated learning supported with empirical studies, including those by Boeakerts, Borkowski, Pintrich, Winne and Zimmerman. Although all authors have a common perception of self-regulated learning, generally speaking, as a cycle in which self-assessment and self-evaluation of the learning process influence the following learning processes, they stress different aspects of this process and the constituent components, e.g., by giving a more motivation-oriented versus a metacognitively weighted definition (Puustinen & Pulkkinen, 2001). The appearance of various models on self-regulated learning, putting the focus on different elements of the concept, goes hand in hand with a wide range of terms which are used in this context (Zeidner, Boekaerts, & Pintrich, 2000). Especially the distinction between self-regulated learning and metacognitive learning strategies is often a fuzzy one that lacks clarification. To cope with this problem, in this article metacognitive strategies are seen as one very important element of self-regulated learning, following a model of self-regulated learning by Boekaerts (1999): self-regulated learning is characterized as an interaction of cognitive, metacognitive and motivational processes, which work together during information processing. Boekaerts' model illustrates the relationship between these three categories of strategies: the first level consists of cognitive strategies, which refer directly to information processing. The second level relates to the use of metacognitive strategies aiming at the regulation of the learning process. The third level illustrates the maintenance of motivation, which is characterized by the willingness of independent goal setting, self-activation, as well as adaptive coping with success and failure (Boekaerts, 1999).

When we use the terms self-regulation competence or skills, we refer to the ability of students to self-regulate their learning (based on the definition of competence by Weinert, 2001), whereas the term self-regulation strategy is used to describe concrete activities aiming at reaching a learning goal in a more efficient way (based on the definition of strategy by Moely et al., 1992). However, the original terminology used by cited authors will be kept when quoting articles in the following.

1.5. Interventions to promote self-regulated learning

Dependent on the respectively underlying model of self-regulated learning, interventions emphasize heterogeneous aspects of the learning process. According to Boekaerts and Corno (2005), earlier interventions to foster students' self-regulation of learning were conducted by means of cognitive-behaviour modification programmes or by directly teaching the strategies. Innovations of later classroom intervention consisted of changes in traditional classroom arrangements in order to establish the responsibility and independence of the learners (Boekaerts & Corno, 2005). This is consistent with Lin (2001), who found that in recent years, metacognitive intervention has changed from a strategy training approach to creating social environments to support metacognition. She also asserts a shift from training content that focuses either on domain-specific knowledge or on knowledge about learning, to a more balanced training programme consisting of both kinds of knowledge (Lin, 2001).

Whereas in the beginning of research on metacognition almost all the investigations were confined to metamemory, today metacognition is studied in a broader context. Metacognitive and metastrategic functions are now investigated in different domains, like text comprehension, mathematics, and problem solving (Kuhn, 2000). Therefore, the implementation of strategy training programmes is integrated into various school subjects.

As pointed out earlier, there is enough empirical evidence for the positive impact of self-regulation on learning which has led to the great research interest in promoting self-regulated learning strategies: first, empirical studies have revealed that students can develop strategies based on their experiences, but the construction of strategies can also be guided in order to acquire self-regulated learning strategies (Paris & Newman, 1990). Second, there seems to be a lack of metacognitive knowledge during the first years at elementary school, since the instruction of learning strategies at school is still rare (Annevirta & Vauras, 2001; Perry et al., 2004). Therefore, these findings show that: (1) self-regulation strategies can be improved through training and (2) that there is a requirement for training these strategies.

More and more research has dealt with supporting self-regulated learning in younger students. Despite all these studies, there is still a need for research in this field to clarify the efficacy of various kinds of intervention (Schunk, 2005). Therefore, it seems to be both interesting and useful to get an overview of these kinds of interventions and their characteristics.

1.6. Research questions

This meta-analysis should therefore investigate the following research questions:

(1) Are interventions to foster self-regulated learning at the elementary school level effective generally?
(2) What types of interventions are most effective?

2. Methods

2.1. Determination of the study sample

2.1.1. Literature search

To get the sample of the study, a literature search had been carried out in the following computerized databases: *PsycInfo* and *ERIC*, as the most common Anglophone databases in the field of educational psychology, as well as *Psyndex*, the German database for psychological literature. As self-regulated learning remains a fuzzy concept with inconsistent terminology, a search exclusively done with the term *self-regulated learning* would not access all studies conducted within this scope. Thus, in addition to the term *self-regulated learning*, the following terms which are used to describe effective learning were used as keywords in order to define the search field, based on the keywords used by Hattie et al. (1996) in their meta-analysis: *study skills, learning strategies, self-regulatory strategies, self-regulatory skills, metacognition, metacognitive skills, metacognitive strategies, self-regulated learning, motivational skills, self-motivation, life long learning, learning to learn, thinking skills, learning processes, cognitive style, cognitive strategies, study habits, learning style, cognitive processes, goal-directed behaviour, self-monitoring, goal-setting, self-control, self-determination, self-management, organizational skills*.

In order to separate interventions which aimed at fostering self-regulated learning from other strategy-related intervention, we employ the following selection strategy: studies were included in the analysis if the educational treatment was explicitly labelled by the term "self-regulated learning", or if the described treatment had characteristics ascribed to self-regulated learning following the above mentioned definition—such as cognitive, metacognitive, and motivational learning strategies.

The respective definition of self-regulated learning of studies was detected by analyzing the theoretical background of the article as well as the operationalization of the variables to measure the construct.

2.1.2. Eligibility criteria

In the first step, the studies found in the literature search were selected by two different raters regarding the following criteria for inclusion. In the second step, a data coding form was developed to assure greater accuracy in a more detailed coding process. Interrater agreement based on the coding with this coding form was in acceptable bounds, ranging between 80 and 100%. If agreement was less then 100%, scoring was done collaboratively, and differences were resolved by discussion. Only 48 of the studies resulting from 30 articles met the eligibility criteria and could be included in the analysis in the end.

Studies were included in the analysis when they met the following eligibility criteria:

(1) Only studies aimed at training effective self-regulated learning at elementary school were considered in this meta-analysis. Therefore, experimental laboratory settings are not included and training had to last more than one single session. The intention of the research was to support and promote self-regulated learning amongst students. The interventions included promotion of cognitive, metacognitive, and/or motivational strategies and focus on strategy application or benefit.
(2) The studies were conducted at elementary school level. As most of the studies were conducted in countries where the first 6 years of schooling are called elementary school, this meta-analysis includes studies conducted from grades 1–6. Grade numbers from the different countries were adjusted so that grade 1 includes students at the age of 5–6, and grade 6 students at the age of 11–12. Interventions conducted with children at kindergarten age or students older than 12 years on average were not included in this analysis.
(3) Studies had to be conducted in a real classroom setting, directed either by regular teachers or by researchers. Despite the general understanding that collaborative learning indirectly supports self-regulated learning (see e.g., Boekaerts & Corno, 2005), for this synthesis, direct strategy instruction in terms of an informed training (Brown, Campione, & Day, 1981) had to be part of the training programme. Interventions without any explicit strategy instruction, which aimed at fostering self-regulated learning only by implementing cooperative learning arrangements in the classroom, are excluded. Computer-mediated (CT) learning environments were too different from the other types of intervention to put them together, so these studies had to be excluded from the analysis, too: as Lou, Abrami, and d'Apollonia (2001) point out, learning with CT might represent different circumstances and contexts from learning without CT. The quality and quantity of learning is not necessarily the same as when CT is not present. In addition, characteristics inherent in the studies with CT, e.g., technology and task desing, might mediate the effects of instruction (Lou et al., 2001). Even within CT instruction, instructional programmes are too different with respect to underlying learning theories, developments in technology, instructional control, or other characteristics) to be taken together as one mediating factor in the meta-analysis (see e.g., Sivin-Kachala & Bialo, 1994). Consequently, one would have to account for these differences by including these CT-specific features as additional predictors. As the number of predictors for modelling is limited due to the sample size, a detailed analysis of the impact of CT instruction on self-regulated learning interventions should be conducted separately. Thus, we did not include computer-based interventions into this review.
(4) To assure the comparability of the different studies, the student sample had to be as homogeneous as possible. Therefore, students have to attend regular schools. Student samples with learning disabilities, from especially low socio-economic status, or showing other distinctive features are not be included in the analysis; e.g., studies that involved particular samples of students (e.g., gifted students) had to be excluded (e.g., Stoeger & Ziegler, 2005).
(5) Concerning the study design, the study has to employ a control group design with longitudinal measurement, and has to provide sufficient descriptive data to calculate effect sizes. The samples had to consist of at least 10 students per treatment group. Studies that did not provide enough pre-test data had to be excluded from the analyses (e.g., Tomic & Kingma, 1997).
(6) As a meta-analysis on learning strategy interventions (Hattie et al., 1996) which includes studies published up to the year 1992 already exists, we only included studies published between 1992 and the beginning of 2006.
(7) Articles had to be written in English, German, or French to be included in the review.

In the first step, the search in the databases yielded abstracts of about 100 articles that seemed to be appropriate for the meta-analysis.

Table 1 gives a summary of the information on each study. If different treatments were compared against a control group, or the same treatment was conducted with students in different grades, each treatment comparison was coded as a single study.

Table 1
Variables coded from the primary studies

Category	Coded information
General information	Name of the authors Name of the institute Publication year Name of the journal
Characteristics of the treatment	Theory of self-regulated learning Training contents (metacognitive, cognitive, and/or motivational aspects as well as training components in form of trained strategies) Length of the training Implementation of the programme (self-directed vs. teacher-directed)
Characteristics of the sample	Sample size Age of the students (Grade 1–3 vs. 4–6)
Type of outcome	Operationalized construct (academic achievement/knowledge about facts, strategy use/application of knowledge about skills, motivation/attitude/self-efficacy) Assessment instrument of the dependent variable (questionnaire, interview, multiple choice test, simulation task, achievement test)
Quality of the assessment instrument	Standardised vs. self-developed with empirical support vs. self-developed without any empirical testing
Characteristics of the study design	Control group design Pre- and post-measures Several intervention groups tested against each other Follow-up measures
Method of analysis and variables; effect sizes if reported	

2.2. Variables coded from the studies

2.2.1. Outcome variables

The developed coding scheme followed instructions for systematic coding (Lipsey & Wilson, 2000; Stock, 1994) which contained the information mentioned in Table 1.

As most of the studies reported outcomes concerning several categories of self-regulated learning – e.g., academic achievement in the different subjects, use of cognitive or metacognitive strategies as well as motivational variables – all outcome measures were coded.

Following a meta-analysis of Dochy, Segers, Van den Bossche, and Gijbels (2003), we also distinguished between the types of assessment instruments that researchers of the primary studies used to evaluate their intervention, which measured knowledge of facts on the one hand – in our analysis, this knowledge is mostly related to the academic subject – and the application of knowledge about cognitive or metacognitive skills and strategies on the other.

The academic knowledge cuts again into the various school subject areas: reading/text comprehension and writing/composition, mathematics and mathematical problem solving, and science and social science. These variables are mostly assessed by means of performance tests.

Concerning the application of learning strategies, the use of cognitive or metacognitive strategies was not distinguished. Such a distinction would be problematic as on the one hand the application of cognitive strategies could also be interpreted as an indicator for metacognition. Metacognitive strategy application on the other hand is often not observable and difficult to register (Veenman, Van Hout-Wolters, & Afflerbach, 2006). Strategy application was measured by interviews or questionnaires (self-report) or via simulation tasks or observation.

In order to combine only homogeneous variables and not to “compare apples with oranges”, we conducted several meta-analyses separately for each of the assessed categories in addition to a synthesis which integrated all variables together.

2.2.2. Potential moderating variables

The variables which were tested as potential moderating variables were grouped into three categories: treatment content-related factors (meaning features directly related to the contents of the intervention, e.g. type of instructed strategy), training context-related factors (meaning features that are related to external aspects of the intervention, e.g. who delivered the training), and study design-related factors (meaning features of the evaluation study as a research project). Table 2 summarizes the potential moderating variables within these three categories.

2.2.2.1. Treatment content-related factors. The following characteristics of the treatment that could influence the efficacy of training programmes were analyzed: the type of instructed strategy, meaning the type of strategy that was trained in the intervention (cognitive, metacognitive, and motivational strategies, each including sub-categories), as well as the underlying theoretical background (focus on metacognition, focus on social-cognition, or focus on motivation, as well as combinations).

Table 2
Potential moderating variables

Treatment-content related factors	Training context-related factors	Study design-related factors
Type of instructed strategy	Grade level	Assessment instrument
Theoretical back-ground	School subject Direction of the training Length of the intervention Integration of group work	

2.2.2.1.1. Type of instructed strategy. As all training programmes included in the meta-analysis aimed at supporting self-regulated learning, the interventions were only grouped for the trained strategy fields. According to the model of Boekaerts (1999), interventions can focus on three different types of strategies of self-regulated learning:

Cognitive strategies. Cognitive strategies refer directly to the treatment of the learned information and are therefore specific for the different domains. Thus, in reading classes those strategies will be applied which consider text comprehension, whereas in mathematics classes problem solving strategies will be used. Cognitive strategies can be divided into four areas (Weinstein & Mayer, 1986):

Repitition strategies: active repetition improves the chance that information will be memorized by transfer to the long-term memory. To remember information, simple repeating without any further understanding of the content does not lead to gain meaning from the material or to process it in a deeper sense.
Elaboration strategies: these serve to support the comprehension process by incorporating new knowledge into already existing cognitive structures. Meaningless contents will be assigned meaning in order to retain it more efficiently.
Organizational strategies: these seek to work out and illustrate important information and relations by grouping single information into super-ordinate units of meaning in order to be processed and memorized more efficiently.
Problem solving strategies: Mayer and Wittrock (1996) define problem solving as a cognitive process aiming at resolving a problem if there is no obvious solution at hand. Within problem solving, a problem is fragmented into sub-goals, which can be solved with the available means. Additionally, problem-solving competence should be multi-dimensional: besides general interdisciplinary reasoning, also domain-specific sub-competencies play a role (Klieme, Funke, Leutner, Reimann, & Wirth, 2001).

2.2.2.1.2. Metacognitive strategies. Metacognition is defined as cognition about cognition, referring to second-order cognitions (Papaleontiou-Louca, 2003). Metacognitive processes can therefore control, monitor and regulate learning and cognitive activities in general. Thus, metacognition enables reflection about one's own learning process on the one hand, and use and regulation of strategic activities on the other hand.

Metacognitive knowledge: most of the models of metacognition discriminate between knowledge of cognition on the one hand and monitoring, controlling and regulating one's cognitive processes on the other hand (Pintrich, 2002). Knowledge of cognition includes the learners understanding of their own memory, their knowledge, and their learning style.
Metacognitive skills: the regulation of cognition can take place along the whole learning process (e.g., Brown, 1978). Prior to learning, planning activities take place in order to predict the result or choose strategies. During learning, monitoring occurs, as well as the rescheduling of strategy use. After learning, the outcome is checked and evaluated against criteria of efficiency (Brown, Bransford, Ferrara, & Campione, 1983).

2.2.2.1.3. Motivation strategies. The above-described cognitive and metacognitive strategies suggest characteristics about effective and self-regulated learning behaviour. However, whether these strategies will be applied also depends on the motivational conditions (Pintrich, 1999). These play a significant role as they influence the initiation and maintenance of learning behaviour. The impact of motivation and volition on learning behaviour could be shown in several studies (see e.g., Schmitz, 2001). Applying self-regulatory strategies may cost students more time and effort than their normal learning. It is therefore important for them to be motivated to use these strategies. As a result, research has increasingly focused on motivational aspects of strategy use.

Causal attribution and self-efficacy beliefs: how learners explain success or failure affects learning behaviour substantially. Their attribution has an impact on motivation as well as on emotions related to learning (Heckhausen, Gollwitzer, & Weinert, 1987) and self-efficacy (Bandura, 1986). As students with high self-efficacy beliefs are more likely to use cognitive and metacognitive strategies (Pintrich, 1999), an attribution style beneficial to motivation should give the learners the impression of being effective for their own learning. It is therefore beneficial for motivation to attribute performance to internal and variable rather than to external and temporarily stable causes (Weiner, 1986).
Action control: however, performance deficits following failure cannot always be explained by a belief of uncontrollability. According to Kuhl's action control theory (1987), the discrepancy between motivation and performance can be due to the state-orientation of a student, focusing his or her metacognitive activity on controlling cognition to facilitate the

analysis of some past, present, or future state. Action-oriented learners concentrate on cognitive activities, which assist the arousal of goal-directed action tendencies (Kuhl, 1987). In order to avoid motivational and volitional problems, learners should shift their attention away from possible origins of the problem to think of potential ways of changing the situation.

Feedback: the learner should be encouraged to ask for feedback and to talk about his/her learning. A detailed analysis of the learning outcome and the factors which led to this result should offer conclusions about the appropriateness of one's own goal setting (are higher or lower goals more appropriate?), as well as the procedure to attain this goal (investing more time and effort; using other strategies?). Strategic learners search for feedback after accomplishing a task in order to draw conclusions about how to improve their learning (see e.g., Butler & Winne, 1995).

2.2.2.1.4. Theoretical background. The theoretical background on which the intervention was based was grouped into learning theories that focus mainly on social-cognitive, metacognitive, or motivational components. The theoretical background of a study includes definitions of self-regulated learning which have an enormous impact on the operationalization of the construct that is the focus of this intervention. Since theories about self-regulated learning differ in relation to the underlying research tradition (see McCaslin et al., 2006), the interventions should be organized in a way that the impact of these different research traditions and foci can be investigated. However, most studies did not only mention one model of self-regulated learning on which the intervention is based, but several. Therefore, we classified the used models into three categories: models which focus more on metacognition (e.g., A. Brown), those which also include social factors and can be classified as social-cognitive models (e.g., B. Zimmerman), as well as models which focus mainly on motivational aspects of learning (e.g., J. Kuhl). If such a focus was not clearly distinguishable, a mixed category (social-cognitive and metacognitive, social-cognitive and motivational, or metacognitive and motivational) was coded.

2.2.2.2. Training context-related factors. Factors that directly influenced the conduction of the intervention consisted of the age of the participating students, the school subject, the type of implementation, the duration of the training, and if group work was used as instruction method.

2.2.2.2.1. Age was coded as the grade level. Age was coded in terms of grade level of the students in the sample of each study, since not all studies reported the mean age of students, and – because of national differences in the assignment of children of certain ages to school grade in the various school systems – was adjusted to grade 1 including the grade level of the first year of schooling (students of around 6 years old) until the sixth year (students of around 12 years old). Due to the empirical evidence of age differences in self-regulated learning mentioned earlier, a comparison between the different elementary grades should reveal the most effective ways to support self-regulated learning as early as possible.

2.2.2.2.2. The school subject. The school subject in whose context the intervention took place was grouped into three categories: reading/writing, mathematics, and a category of other performance of other school subjects, e.g. science and social science.

2.2.2.2.3. Direction of the intervention. The intervention was conducted either by researchers or by regular teachers. On the one hand, the development of self-regulated learning is not only stimulated by increasing age, but also by the learning environment (Chung, 2000). The quality of the learning environment is highly influenced by teachers' attitude towards instruction methods. Teachers consequently play a major role in establishing or preventing self-regulated learning in students. On the other hand, strategic learning remains a fuzzy concept for most teachers, and they attach minor importance to its instruction (Waeytens, Lens, & Vandenberghe, 2002). Accordingly, teachers implement only a little instruction of strategy in their classrooms (Hamman, Berthelot, Saia, & Crowley, 2000; Moely, Santulli, & Obach, 1995). Hence, it seems appropriate to assume a difference in the effectiveness of teacher-directed versus researcher-directed training implementation, as researchers keep the importance of self-regulated learning in mind. However, teachers would have the possibility to link the strategy instruction to their regular teaching which should be helpful for fostering students' transfer of strategies to other academic contexts. The studies were therefore coded according to this grouping. All interventions carried out by teachers were based on teacher training. However, since only few studies report details about teacher training like length or content, further information about quality and intensity of teacher preparation could not be included in the analyses.

2.2.2.2.4. Length of the intervention. Length of the intervention should be recorded as the number of training sessions as well as amount of months spent with training. Both variables were provided for almost all studies or could be reconstructed from the description of the studies, and were included in the analyses as a continuous variable. Shorter interventions can have the advantage that participants (teachers and students) do not loose interest before it is completed. However, longer interventions provides the opportunity to train and practice strategy use in more detail and more intensively.

2.2.2.2.5. The integration of group work. The integration of group work as a teaching method in the intervention was coded by authors mentioning students working in groups during the training with 1 (integration of group work) or 0 (no group work). Following Johnson, Johnson, and Smith (2007), group work is an instruction method where individuals work together to achieve shared goals, in order to maximize their own and each other's learning, including all kinds of learning arrangements in which students temporarily work together in pairs or small groups (Pauli & Reusser, 2000). As the focus of this meta-analysis was to investigate the instruction of self-regulated learning, we did not differentiate between sub-types of group work, like e.g., cooperative or collaborative working.

2.2.2.3. Study design-related factors. The factors linked to the design of the intervention do not directly influence the training efficacy; still an impact on the training outcome is supposable. We therefore examined the relation between study design features and the effect sizes of the respective study.

2.2.2.3.1. The type of assessment instrument. The type of assessment instrument that was used to assess students' outcomes of the pre-post-evaluation of the intervention was coded. Coding included the following categories: primary studies had registered academic achievement by means of knowledge tests or multiple-choice tests; the application of cognitive or metacognitive strategies by problem solving, thinking aloud, or simulation tasks, as well as by questionnaires or interviews. The studies that measured the motivational aspects of learning also used questionnaires or interviews to evaluate the training effects.

2.3. Comparing and combining results

2.3.1. Calculating effect sizes

In the first step, the findings of the primary studies had to be transformed into a numerical scale to allow meaningful comparison amongst them (Lipsey & Wilson, 2000). Mean values, standard deviations or, if not available, F-values, and sample sizes were extracted from each primary study to compute effect sizes for every single primary study outcome, based on the standardized mean difference *d*. According to Hedges and Olkin (1985), the effect size *d* was computed as the difference between the mean values of experimental and control groups as well as between pre-test and post-test group means, divided by the pooled standard deviation. Since the reliability of variables was not available from all of the primary studies, effect sizes could not be adjusted for unreliability (Hunter & Schmidt, 1990). Better than adjusting only some effects while others remain unadjusted, effect sizes were all left unadjusted under the assumption that they are more comparable, even if less accurate (Lipsey & Wilson, 2000).

The quantitative outcome variables were divided into the different categories outlined above. We calculated effect size estimates for each outcome variable of which the study reported sufficient information to allow computations.

The assignment of subjects to treatment or control group within the primary studies could not be randomized as the interventions took place in real classroom settings and subjects remained in their regular classes. Therefore, doubts about pre-test differences cannot be excluded (Rustenbach, 2003). These potential pre-test differences should be taken into account. Following the proceeding of another meta-analysis (Wilson & Lipsey, 2000), the post-test effect sizes were adjusted for pre-test differences between treatment and control group by subtracting the pre-test effect size from the post-test effect size (Rustenbach, 2003). In cases in which the pre-test values were not reported, studies were only included in the analysis if they affirmed that no significant pre-test differences were found between the groups. Studies without any pre-test measures were excluded from the analysis.

As only four studies reported follow-up test results, we did not compute effect sizes for these four follow-up tests.

2.3.2. Calculating a mean effect size

In order to describe the distribution of the effect sizes, we calculated weighted averaged effect sizes for every outcome category. As the effect sizes are based on different samples with differing sizes, each effect size had to be weighted in order to avoid situations in which smaller samples with greater sampling error contribute as much to the mean effect size as larger samples (Hedges & Olkin, 1985). The mean effect size was therefore computed by weighting each effect size by the inverse of its variance. Confidence intervals of 95% were determined to indicate the precision of the estimated mean effect size (Lipsey & Wilson, 2000).

By calculating average effect sizes, the statistical independence of the data must be maintained. However, most of the studies included in this analysis assessed the various components of self-regulated learning by means of multiple outcome variables, which led to several dependent effect sizes per study. Dependency amongst effect sizes also appears when studies compared several treatment groups to one single control group.

To handle this problem, we averaged those effect sizes which assessed the same construct (Rosenthal, 1991), and assigned those that assessed different constructs to different meta-analyses (Hunter & Schmidt, 1990), each computed for one single outcome category separately. To avoid an inflation of the sample size when effect size means are computed, the number of subjects was divided by the number of effect sizes averaged. In case of comparisons of two treatment groups with only one single control group, we included only half of the numbers of the control group sample in the analysis. This adjustment of sample size took place before calculating the effect sizes of the primary studies. Therefore, the variances of these effect sizes were already adjusted when the weighting was done.

2.3.3. Mixed effects models

The homogeneity test represented by the *Q* statistic, which tests if the dispersion of effect sizes around the average is not greater than would be expected from the sampling error alone, indicates that the overall mean effect size does not represent the outcomes of the primary studies accurately (Hedges & Olkin, 1985). Therefore, the effect sizes are grouped according to the different constructs. However, the distribution for effect sizes – grouped into mathematics achievement, motivational outcome measures, and strategy use – also turned out to be heterogeneous. This indicates the existence of differences between the studies that should be taken into account by applying a random effects model, which allows sampling error on the study level. However, as we included all relevant levels of the moderator variables, this moderator effect should be assumed as fixed. We therefore chose a mixed effects model, which assumes a random between-study effect and a fixed moderator effect (Overton, 1998).

2.3.4. Analyzing moderator effects

Tests for the homogeneity of primary study effect sizes were applied to check whether study results all estimated the same population effect size. We tested the homogeneity of the effect size distribution by conducting a χ^2-test for the Q statistic (Hedges & Olkin, 1985) with a statistically significant Q indicating heterogeneity of the effect sizes. As there are several reasons why effect size distributions can be found to be heterogeneous – extreme effect size values that deviate greatly from the distribution of effect size are unrepresentative of the results in the research area and can influence the meta-analytic statistics in a spurious way – those outliers should be detected and excluded from the analysis. According to the suggestion of Lipsey and Wilson (2000), effect sizes that differed from the mean effect size by more than three standard deviations were excluded from the analysis.

Differences among the effect sizes could also be traced to different study characteristics. The test of the relationship between the effects and various study characteristics, which were coded as discrete variables, was aided by categorical models. To analyze the impact of study characteristics on the variability of the effect size distribution, we computed an analogy to analysis of variance (for categorical variables) and meta-analytic regressions (for continuous variables) with the potential moderating study characteristics as an independent variable. Effect sizes were tested for consistency across and within classes with models providing a between-class effect being analogous to one of the main effects in an ANOVA design, as well as a test of the homogeneity of the effect sizes within each class. In addition to this within-class statistic Q_w indicating if the effect sizes of the final classes are internally homogeneous, the Q_b statistic determined whether the average effect size differed over classes (Hedges & Olkin, 1985). The factors that might enhance the training effectiveness were grouped into three clusters: training context-related features, treatment content-related factors, and those related to the study design.

3. Results

Most of the analyzed studies did not only report gains in academic performance but also the change of motivational variables or strategic behaviour. These heterogeneous outcome measures should not be thrown together. To be able to investigate the training effects in these different categories one by one, outcome measures were grouped according to the recorded construct. All analyses were conducted once for all outcome measures together, as well as separately for each category. We therefore conducted one meta-analysis for all dependent variables together, as well as for all academic outcome measures together, and five separate meta-analyses for each outcome group:

- academic performance in mathematics;
- academic performance in reading and writing;
- other performance;
- use of cognitive or metacognitive strategies;
- use of motivational strategies.

All results will be presented for these outcome categories. To demonstrate the impact of training characteristics on the effect sizes in the respective outcome groups, results are first arranged in relation to the potential moderating variables—i.e. training context-related, treatment content-related, and study design-related factors. Second, the results are presented for each outcome category within each of these three chapters.

3.1. General characteristics of the studies included in the meta-analysis

The summary of the characteristics of the 48 studies, which met the eligibility criteria for the meta-analysis, is shown in Table 3.

3.2. Effect sizes for the outcomes of self-regulated learning intervention

Two hundred and sixty-three effect sizes arose from these 48 studies resulting from 30 articles. Self-regulated learning is a multivariable construct, which was in most cases evaluated by several outcome constructs. The outcome-grouped distributions of effect sizes were examined for outliers differing more than three standard deviations from the mean of all effect sizes within a group and adjusted by eliminating them from the effect size distributions (Lipsey & Wilson, 2000). The histogram in Fig. 1 illustrates the distribution before adjustment (unweighted mean effect size). After this procedure, the overall distribution consisted of 263[1] effect sizes, which were grouped as follows: 102 effect sizes show gains in academic

[1] Since separate meta-analyses were conducted for the different outcome categories, outlier analyses took place for every single meta-analysis. Therefore, the sum of the amount of effect sizes per meta-analysis does not result in the number of effect sizes for the overall meta-analysis after its outlier analysis.

Table 3
Summary of study and effect size characteristics

Variables	$n = 263$ (effect sizes)	$N = 48$ (studies)
Relationship of treatment content-related factors		
Cognitive strategy training		
Yes	193	37
No	70	11
Metacognitive strategy training		
Yes	221	41
No	42	7
Motivation strategy training		
Yes	88	12
No	175	36
Relationship of training context-related factors		
Duration of the intervention	*M* = 23.30 (S.D. = 14.93)	*M* = 24.33 (S.D. = 17.42)
Implementation of the programme		
Researcher-directed	135	22
Teacher-directed	128	26
Age	*M* = 4.34 (S.D. = 1.13)	*M* = 4.21 (S.D. = 1.30)
Relationship of study design-related factors		
Assessment instruments		
Problem-solving task	117	
Questionnaire	65	
Multiple choice test	12	
Simulation of a task	38	
Others (e.g., interview, thinking-aloud protocol)	31	
Sample size	*M* = 78.8 (S.D. = 71.82)	
Publication year	*M* = 1997.59 (S.D. = 4.56)	

performance (55 effect sizes for academic performance in reading and writing, 25 effect sizes for mathematics, and 22 effect sizes in the category of other performance). One hundred and thirteen effect sizes illustrate the results concerning cognitive and metacognitive strategy use, and 48 effect sizes focused on motivation. The plots in Fig. 2 display the sample distribution of effect sizes in these subgroups.

Effect Sizes Stem-and-Leaf Plot

```
Frequency    Stem &  Leaf

   1,00       -0 .  &
    ,00       -0 .
    ,00       -0 .
  13,00       -0 .  222222&
  24,00       -0 .  00000000011
  56,00        0 .  0000000000000111111111111111
  45,00        0 .  2222222222222333333333
  52,00        0 .  44444444445555555555555555
  40,00        0 .  66666666677777777777
  31,00        0 .  888888888899999
  22,00        1 .  0000011111
  14,00        1 .  222233
  11,00        1 .  44445
  14,00        1 .  666777
   7,00        1 .  889
  10,00        2 .  00111
   6,00        2 .  233
   2,00        2 .  4
  10,00 Extremes    (>=2,5)

Stem width:     1,00
Each leaf:      2 case(s)

& denotes fractional leaves.
```

Fig. 1. Effect size distribution before outlier analysis.

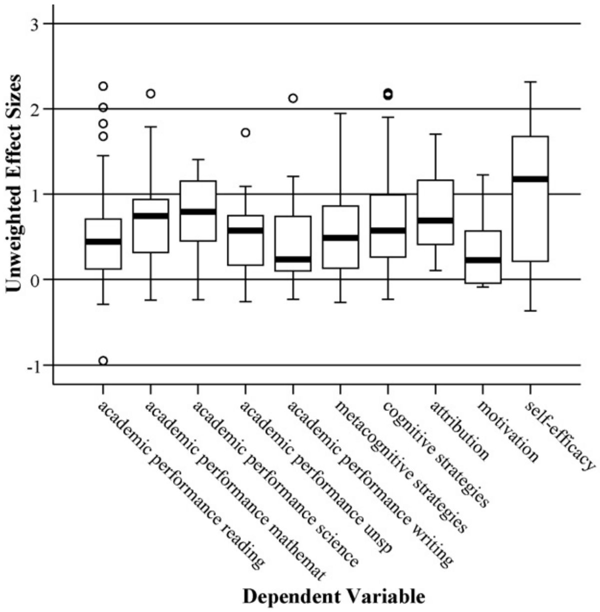

Fig. 2. Effect size distribution grouped according to the outcome category.

3.3. *Average effect of self-regulated learning interventions*

Mean effect sizes were computed as described earlier, underlying the assumption of a random effects model. Table 4 shows the aggregated effect sizes for each outcome construct, with the respective confidence intervals to indicate the degree of precision of the estimated mean effect sizes. The weighted overall mean effect size d was .69 with a standard error .03. As the confidence interval does not include zero, this mean effect size as well as the mean effect sizes for the subgroups are statistically significant. The overall mean effect size for academic performance is $d = .62$ (S.E. = .05), whereas the mean for mathematics performance is highest with $d = 1.00$ (S.E. = .13), followed by the mean for the category of other performance with $d = .64$ (S.E. = .09), and for reading and writing performance with $d = .44$ (S.E. = .06). The aggregated effect sizes that measure the use of cognitive and metacognitive strategies yield a mean effect sizes of $d = .73$ (S.E. = .04). For motivational aspects the mean effect size is $d = .76$ (S.E. = .09).

3.4. *Relationship between moderating variables and effect sizes*

The impact of the above-mentioned factors (treatment content-related factors, training context-related features, and those related to the study design) on the effect size variability will be presented for all outcome categories: comparing the effect sizes for the different outcome categories revealed significant differences between all different categories ($Q_b = 26.88$, $p < .01$), as well as between the three categories of academic performance outcomes ($Q_b = 21.41$, $p < .01$). Effect sizes were highest for outcomes that measure mathematics performance, while those for the category of other performance and reading/writing performance turned out to be only moderate. Effect sizes for students' strategy use and their motivational outcomes can be considered as moderate to high (see Table 5).

3.4.1. *Relationship between treatment content-related factors and effect size*

3.4.1.1. Theoretical approach of the intervention. Analyses across all variables revealed the highest effect sizes for interventions based on social-cognitive learning theories, followed by studies based on both, social-cognitive and metacognitive

Table 4
Mean effect sizes

	Mean ES (S.E.)	−95% CI	+95% CI
All dependent variables	.69 (.03)	.64	.75
Academic performance overall	.62 (.05)	.53	.71
Reading/writing performance	.44 (.06)	.34	.55
Mathematics performance	1.00 (.13)	.75	1.24
Other performance	.64 (.09)	.46	.83
Strategy use	.73 (.04)	.65	.80
Motivational outcomes	.76 (.09)	.59	.94

Table 5
Mean effect sizes grouped according to the outcome category

Mean ES (S.E.)	All dependent variables*	Academic performance overall*
Reading/writing performance	.45 (.06)	.45 (.06)
Mathematics performance	.98 (.09)	.98 (.09)
Other performance	.64 (.10)	.64 (.10)
Strategy use	.73 (.04)	
Motivational outcomes	.74 (.07)	
Random effects variance component, *v*	.17	.22

* Significant differences between categories.

Table 6
Mean effect sizes grouped according to the theoretical background

Mean ES (S.E.)	Metacognitive background	Motivational background	Social-constructivist background	Metacognitive and social-constructivist background	Random effects variance component, *v*
All dependent variables*	.59 (.05)	.43 (.07)	.89 (.04)	.59 (.19)	.19
Academic performance overall*	.58 (.08)	.33 (.10)	.95 (.09)	1.44 (.55)	.21
Mathematics performance	.89 (.18)	.33 (.59)	1.15 (.19)	1.33 (.66)	.34
Reading/writing performance*	.38 (.08)	.27 (.10)	.76 (.11)	–	.13
Other performance*	.53 (.10)	.43 (.09)	1.25 (.12)	–	.04
Strategy use*	.48 (.06)	.71 (.11)	.95 (.05)	.44 (.17)	.12
Motivational outcomes	1.06 (.22)	.24 (.29), $n=4$	.76 (.10)	–	.32

* Significant differences between categories.

theories, as well as those based only on metacognitive theories. Motivational learning theory background led to lowest effect sizes ($Q_b = 38.60$, $p < .01$). For the overall measure of academic performance, the results are similar: here, a combination of metacognitive and social-cognitive learning theories leads to the highest effect sizes, but also a social-cognitive background leads to high effects. Interventions based on metacognitive theories showed moderate effects, and those with a motivational background showed the lowest ($Q_b = 25.05$, $p < .01$). More detailed analyses for academic performance outcomes revealed again the highest effects of trainings based on social-cognitive theories, moderate effects for those based on metacognitive theories, and the lowest effects for those based on learning theories with focus on motivation ($Q_b = 12.37$, $p < .01$ for reading/writing performance, and $Q_b = 31.59$, $p < .01$ for the category of other performance). For outcomes assessing the strategy use, effect sizes were highest again for interventions based on social-cognitive theories, but this time a motivational background led to higher effects than a metacognitive one ($Q_b = 38.66$, $p < .01$). Regarding the motivational outcomes, differences were not significant (see Table 6).

3.4.1.2. Type of strategy. Analyses of the effectiveness of the different types of instructed strategies revealed a significant difference for the overall measure ($Q_b = 26.10$, $p < .01$): effect sizes were highest for combinations of metacognitive and motivational or metacognitive and cognitive strategy instruction, followed by the combination of metacognitive and cognitive, as well as cognitive and motivational strategies. The instruction of only motivational strategies led to high effects, too, and teaching metacognitive strategies also revealed moderate effects, while the instruction of cognitive strategies alone only led to low effect sizes. Analyzing the performance data did not show any significant differences between the instruction of the different types of strategies. Regarding students' use of strategies, the combination of instructing different types of strategies led to high effects, while the instruction of exclusively cognitive, metacognitive, or motivational strategies revealed moderate effects ($Q_b = 13.71$, $p < .05$). The analyses of motivational outcomes should be interpreted carefully due to the small number of effect sizes per cell. When regarding only those categories with more than five effect sizes, it becomes clear that interventions limited to instructing cognitive strategies led to the lowest effect sizes ($Q_b = 53.08$, $p < .01$) (see Table 7).

Table 7
Mean effect sizes grouped according to the group of instructed strategy

Mean ES (S.E.)	All dependent variables*	Academic performance overall*	Reading/ writing performance	Mathematics performance	Other performance	Strategy use*	Motivational outcomes*
Metacognitive	.70 (.06)	.69 (.10)	.45 (.09)	1.09 (.21)	1.15 (.48)	.54 (.08)	2.56 (.43), $n=2$
Cognitive	.37 (.08)	.13 (.20)	.15 (.22)	.02 (.51)	.13 (.31)	.58 (.10)	.17 (.17)
Metacognitive and cognitive	.78 (.05)	.69 (.11)	.50 (.13)	1.03 (.20)	.68 (.11)	.81 (.06)	.81 (.13)
Motivational	.94 (.17)	1.36 (.31)	–	1.36 (.32)	–	.59 (.20)	1.34 (.61), $n=1$
Metacognitive and motivational	1.13 (.18)	1.23 (.31)	–	1.23 (.32)	–	.97 (.20)	1.69 (.64), $n=1$
Cognitive and motivational	.69 (.06)	.55 (.08)	.46 (.09)	.45 (.31)	.67 (.11)	.85 (.09)	.82 (.14)
Random effects variance component, *v*	.20	.23	.13	.25	.15	.13	.27

* Significant differences between categories.

Table 8
Mean effect sizes grouped according to the instructed cognitive strategy

Mean ES (S.E.)	All dependent variables*	Academic performance overall*	Reading/writing performance	Mathematics performance	Other performance*	Strategy use*	Motivational outcomes*
No cognitive strategy	.62 (.06)	.63 (.09)	.35 (.10)	1.04 (.19)	1.15 (.33), n = 1	.55 (.07)	1.74 (.36), n = 3
Elaboration strategy	.97 (.06)	.84 (.11)	.68 (.12)	.78 (.46), n = 2	1.20 (.10)	1.19 (.09)	.85 (.10)
Organization strategy	–	–	–	–	–	–	–
Problem solving strategy	.87 (.07)	.98 (.13)	.78 (.23)	.99 (.20)	.96 (.25), n = 1	.72 (.08)	1.03 (.19)
Elaboration and organization	.42 (.06)	.37 (.09)	.37 (.09)	–	.37 (.07)	.56 (.07)	.01 (.20)
Elaboration and problem solving	.33 (.15)	.42 (.25)	.20 (.29)	–	.64 (.18), n = 2	.23 (.28)	.30 (.25), n = 4
All three strategies	.94 (.27)	–	–	–	–	.94 (.23)	–
Random effects variance component, v	.19	.23	.14	.37	.03	.13	.24

* Significant differences between categories.

3.4.1.3. Type of cognitive strategy. More detailed analyses about the impact of the instruction of different types of cognitive strategies on the training effect revealed the highest effect sizes if all three types of strategies – elaboration, organization, and problem solving strategies – were instructed, but also for exclusive instruction of elaboration or problem solving strategies. If interventions did not include any instruction of cognitive strategies at all, the effect sizes became moderate. Only low effects were found for interventions which combined the training of two types of cognitive strategies ($Q_b = 61.74$, $p < .01$). Organization strategies were the only type of cognitive strategies, which were never trained without any other cognitive strategy. Regarding academic performance outcomes, the instruction of exclusively elaboration or problem solving strategies led to the highest effects, followed by a moderate effect for interventions which did not include any cognitive strategy instruction ($Q_b = 19.21$, $p < .01$). More detailed analyses of the performance data showed significant differences for the category of other performance. The results of the analyses of other performance data have to be considered carefully due to the small numbers of effect sizes in some categories ($Q_b = 49.17$, $p < .01$). The instruction of only elaboration strategies led to the highest effects in this category. The investigation of students' strategy use again demonstrated the highest effects for interventions training all three types of cognitive strategies, or exclusively elaboration or problem solving strategies. Again, effect sizes are moderately higher for interventions which did not train cognitive strategies at all than for those training two types of cognitive strategies together ($Q_b = 44.09$, $p < .01$). Considering the outcomes measuring motivation, the same picture appears, except that no interventions, which measured motivational outcomes, also included all three types of cognitive strategies in their training. Concerning the motivation, interventions seem to lead to the highest effects when not including cognitive strategy instruction at all, but focusing on other types of strategies. However, this result is based only on three effect sizes. The instruction of only elaboration or only problem solving strategies revealed a higher effect than the combination of two types ($Q_b = 21.07$, $p < .01$) (see Table 8).

3.4.1.4. Type of metacognitive strategy. More detailed analyses of the impact of concrete metacognitive strategies display the highest effect sizes for the combined training of planning and monitoring strategies or planning and evaluation strategies. The instruction of single metacognitive strategies also led to moderate to high effects but did not attain higher effects than interventions that did not foster metacognitive strategies at all. The lowest effect sizes were found for the training of monitoring and evaluation strategies, as well as for those instructing all three types of metacognitive strategies at once ($Q_b = 37.96$, $p < .01$). Regarding the performance data, the difference between the training of the metacognitive strategy categories became significant only for the reading/writing performance and the category of other performance: when assessing the reading/writing performance, effect sizes were highest for interventions that trained planning strategies or monitoring strategies alone. For other performance, highest effect sizes were found for the combined training of planning and monitoring strategies, as well as for the separate instruction of these two types of metacognitive strategies. The effects on students' strategy use were found to be very high for interventions that promoted two types of metacognitive strategies together, in particular if the instruction of planning strategies was part of this strategy combination. However, the training of the three types of metacognitive strategies altogether, as well as the promotion of a single type of metacognitive strategy did not attain higher effect sizes than interventions which did not promote metacognition at all ($Q_b = 49.58$, $p < .01$). The analyses of the motivational outcomes did not reveal any significant effect (see Table 9).

3.4.1.5. Type of metacognitive reflection. Besides the instruction of metacognitive strategies, analyses were conducted to investigate the impact of promoting students' metacognitive reflection as part of an intervention. Effect sizes of the overall data were highest for interventions that both provided students' with knowledge about strategies and illustrated the benefits of applying the trained strategies, or even stimulated metacognitive reasoning in addition. Training programmes, that included only one of these types of reflection, or that focused on reasoning and one of the other two types, did not lead to higher effect sizes than training programmes that did not promote any type of metacognitive reflection ($Q_b = 14.58$, $p < .05$). No significant impact of the type of metacognitive reflection that is stimulated was found for any of the performance outcomes, except for strategy use and motivational outcomes. These results however have to be interpreted cautiously, taking into account the small number of effect sizes in some cells of the ANOVA. The effect sizes of students' strategy use were

Table 9
Mean effect sizes grouped according to the instructed metacognitive strategy

Mean ES (S.D.)	All dependent variables*	Academic performance overall	Reading/ writing performance*	Mathematics performance	Other performance*	Strategy use*	Motivational outcomes
No metacognitive strategy	.83 (.05)	.66 (.13)	.59 (.14)	1.36 (.34)	.31 (.13)	.87 (.06)	.86 (.12)
Planning strategy	.48 (.08)	.60 (.17)	.72 (.18)	.38 (.32)	.64 (.19)	.49 (.10)	.30 (.21)
Monitoring strategy	.73 (.11)	.91 (.17)	.73 (.20)	1.16 (.31)	.92 (.24)	.29 (.18)	.81 (.31)
Evaluation strategy	.68 (.08)	.69 (.13)	.43 (.12)	1.16 (.24)	–	.60 (.09)	1.51 (.47)
Planning and monitoring	.86 (.10)	.78 (.14)	.50 (.10)	–	1.25 (.11)	1.50 (.23)	.58 (.31)
Planning and evaluation	1.50 (.21)	–	–	–	–	1.46 (.19)	1.59 (.57)
Monitoring and evaluation	.37 (.23)	.35 (.37)	–	.83 (.40)	–	.76 (.40), $n = 1$	.68 (.59)
All three strategies	.56 (.06)	.48 (.09)	.21 (.10)	.95 (.22)	.44 (.08)	.58 (.07)	.70 (.23)
Random effects variance component, v	.19	.25	.13	.29	.04	.12	.31

* Significant differences between categories.

Table 10
Mean effect sizes grouped according to the instructed metacognitive reflection

Mean ES (S.E.)	All dependent variables*	Academic performance overall	Reading/ writing performance	Mathematics performance	Other performance	Strategy use*	Motivational outcomes*
No metacognitive reflection	.66 (.05)	.60 (.08)	.32 (.08)	1.23 (.21)	.64 (.12)	.77 (.06)	.46 (.12)
Reasoning	.62 (.10)	.83 (.17)	.73 (.20)	.88 (.27)	1.15 (.50)	.43 (.12)	.43 (.41), $n = 2$
Knowledge about strategies	.61 (.12)	–	–	–	–	.74 (.12)	.31 (.21)
Benefit of strategy use	.41 (.22)	.61 (.42)	–	.33 (.61), $n = 1$	1.14 (.65)	.36 (.37), $n = 1$	.31 (.33), $n = 2$
Reasoning and knowledge	.37 (.24)	.35 (.37)	–	.83 (.44), $n = 2$	–	.76 (.41), $n = 1$	.68 (.50), $n = 1$
Reasoning and benefit	.52 (.16)	.66 (.59)	–	–	.66 (.51)	.33 (.15)	1.10 (.37), $n = 2$
Knowledge and benefit	.86 (.06)	.55 (.12)	.47 (.11)	.67 (.33), $n = 4$	.64 (.32)	.95 (.08)	1.04 (.12)
All three reflections	.79 (.08)	.73 (.12)	.54 (.11)	1.32 (.37), $n = 3$	.41 (.26)	.56 (.11)	2.21 (.35), $n = 2$
Random effects variance component, v	.20	.26	.13	.37	.17	.13	.21

* Significant differences between categories.

highest when knowledge about strategies and the benefit of strategy use were promoted within the training. The integration of the other types of metacognitive reflection into the training did not lead to higher effect sizes than interventions that left out metacognitive reflection ($Q_b = 23.48$, $p < .01$) entirely. Effect sizes that measured students' motivational outcomes became very high for interventions, which included all three types of metacognitive reflection in the programme, as well as for those that stimulated metacognitive reasoning and promoted the benefits of strategy use at the same time. Yet, these mean effect sizes are based only on two effect sizes. Providing students' with strategic knowledge and benefits of strategy use also resulted in very high effects ($Q_b = 36.07$, $p < .01$) (see Table 10).

3.4.1.6. Type of motivational strategy. The picture of the analyses for the impact of the instruction of different types of motivational strategies is consistent across all outcome categories. We did not find any significant effects for the subcategories of academic performance, though we did find significant differences for the overall category of academic performance. For all these outcome categories, analyses revealed very high effect sizes if the intervention focused on feedback as part of the training content. Action control and causal attribution strategies did not account for higher effect sizes than did interventions without any instruction of motivational strategies at all. Only for students' strategy use, the instruction of action control strategies led to high effects ($Q_b = 23.39$, $p < .01$) (see Table 11).

3.4.1.7. Group work. A comparison between interventions which used group work as an instruction method and those that did not yield significant differences in effect sizes for the overall measure of variables ($Q_b = 24.34$, $p < .01$), for the overall

Table 11
Mean effect sizes grouped according to the instructed motivational strategy

Mean ES (S.E.)	All dependent variables*	Academic performance overall*	Reading/ writing performance	Mathematics performance	Other performance	Strategy use*	Motivational outcomes*
No motivational strategies	.65 (.03)	.58 (.07)	.47 (.07)	.89 (.17)	.53 (.17)	.69 (.04)	.66 (.11)
Resource strategy	–	–	–	–	–	–	–
Causal attribution strategy	.51 (.09)	.64 (.17)	.37 (.17)	1.10 (.38)	.82 (.45)	.50 (.14)	.32 (.25)
Action control strategy	.53 (.07)	.49 (.10)	.32 (.10)	–	.67 (.13)	.78 (.12)	−.23 (.41)
Feedback strategy	1.53 (.09)	1.41 (.17)	1.07 (.27)	1.19 (.25)	.96 (.45)	1.15 (.14)	1.40 (.17)
Feedback and causal attribution	.33 (.21)	.33 (.48)	–	–	–	–	–
Random effects variance component, v	.17	.23	.13	.38	.17	.13	.29

* Significant differences between categories.

Table 12
Mean effect sizes grouped according to the inclusion of group work as instruction method

Mean ES (S.E.)	All dependent variables*	Academic performance overall*	Reading/ writing performance	Mathematics performance	Other performance	Strategy use*	Motivational outcomes*
Group work	.80 (.04)	.74 (.07)	.53 (.07)	1.11 (.14)	.47 (.18)	.77 (.04)	.89 (.10)
No group work	.48 (.05)	.50 (.08)	.33 (.09)	.67 (.23)	.70 (.11)	.56 (.07)	.23 (.20)
Random effects variance component, v	.20	.24	.13	.29	.16	.14	.34

* Significant differences between categories.

measure of academic performance measures ($Q_b = 5.47$, $p < .05$), as well as for students' strategy use ($Q_b = 5.60$, $p < .05$) and their motivation ($Q_b = 8.49$, $p < .01$). For these entire outcome categories, effect sizes were significantly higher for interventions that did not train students by means of group work than for those that did (see Table 12).

To get a more detailed picture about the relationship of the variable *group work*, correlations were analyzed.

3.4.1.8. Correlations between group work and other variables. Interventions that used group work as an instruction method:

- were significantly based on a theoretical background that focuses on motivation more and on theoretical backgrounds focusing on social-cognitive principles less;
- instructed more elaboration, organization, and problem-solving strategies;
- instructed more planning and monitoring strategies, but provided students with strategic knowledge less and emphasized the benefit of using strategies less;
- included more instruction of action control and causal attribution strategies, but less feedback;
- disposed of a higher number of sessions;
- were conducted in the context of reading/writing.

3.4.2. Relationship between training context-related factors and effect size

3.4.2.1. School subject. We distinguished studies conducted in the context of mathematics instruction (92 effect sizes), reading or writing instruction (114 effect sizes), and others (57 effect sizes), including all other school subjects, e.g. science, social science, etc. Overall, interventions differed significantly in effectiveness in relation to the school subject within which the study took place ($Q_b = 13.82$, $p < .01$). The effect sizes for academic performance revealed a similar result ($Q_b = 9.19$, $p < .05$): effect sizes are highest for interventions conducted in the context of mathematics instruction (Mean ES = .82), followed by those in the context of reading and writing instruction (Mean ES = .55). The category of other performance revealed significantly lower effect sizes (Mean ES = .49). Effect sizes were approximately equally distributed over these three categories. Concerning the use of metacognitive and cognitive strategies, the effect sizes did not differ significantly between the school subjects. For all categories the mean effect sizes ranged around $d = .7$. Focusing on the motivational outcomes, effect sizes were significantly highest ($Q_b = 7.65$, $p < .05$) again for interventions related to mathematics instruction (Mean ES = 1.04), but also the context of reading and writing led to high effects (Mean ES = .72). Only two effect sizes could be computed for the category of other performance, so that no mean effect size could be estimated for this category (see Table 13).

3.4.2.2. Length of training. The duration of the interventions was measured by length of the intervention in months as well as by number of training sessions. Except for the category of other performance, no significant impact of the length of the training could be found. For the category of other performance, analyses revealed that interventions had significantly higher effects with a decreasing number of months ($Q_b = 7.16$, $p < .01$; $B = -.04$, $p < .01$). This effect did not occur when investigating the impact of the number of training sessions.

3.4.2.3. Direction of the training. Taking all outcome measures together, effect sizes are significantly higher if the intervention was directed by researchers than by regular teachers ($Q_b = 21.02$, $p < .01$). The same results occur for measures of academic performance ($Q_b = 16.38$, $p < .01$). However, when splitting the analyses for the different types of academic performance, one

Table 13
Mean effect sizes grouped according to the school subject

Mean ES (S.E.)	Mathematics	Reading and writing	Others	Random effects variance component, v
All dependent variables*	.82 (.05)	.67 (.04)	.55 (.06)	.17
Academic performance*	.82 (.08)	.55 (.08)	.49 (.08)	.19
Strategy use	.77 (.06)	.70 (.06)	.69 (.08)	.14
Motivational outcomes*	1.04 (.17)	.72 (.11)	−.23 (.44), $p = .61$, $n = 2$	.34

* Significant differences between categories.

Table 14
Mean effect sizes grouped according to the direction of the training

Mean ES (S.E.)	All dependent variables*	Academic performance overall*	Mathematics performance	Reading/ writing performance*	Other performance*	Strategy use*	Motivational outcomes
Researcher-directed	.84 (.04)	.87 (.08)	.99 (.15)	.64 (.10)	1.06 (.10)	.80 (.06)	.84 (.10)
Teacher-directed	.57 (.04)	.46 (.06)	1.00 (.26)	.36 (.07)	.41 (.08)	.65 (.05)	.57 (.16)
Random effects variance component, *v*	.19	.22	.35	.13	.05	.14	.32

* Significant differences between categories.

can see that the difference is not significant for outcomes measuring performance in mathematics anymore, but only for performance in reading and writing ($Q_b = 5.32$, $p < .05$), as well as for the category of other performance ($Q_b = 25.42$, $p < .01$). The effect sizes for students' use of strategies indicate again that interventions conducted by researchers lead to higher effects than those conducted by teachers ($Q_b = 4.09$, $p < .05$). With regard to motivational outcomes, no significant differences were found due to the direction of the training (see Table 14).

To get a more detailed picture of the relationship of the variable *direction of the training*, correlations were analyzed.

3.4.2.4. Correlations between direction of the training and other variables. Interventions which were directed by the regular teachers:

- were based on motivational theoretical background more and based on social-cognitive theoretical background less;
- instructed more organization strategies;
- included the instruction of metacognitive strategy and reflection;
- included the instruction of action control strategies and feedback;
- disposed of a higher number of sessions;
- took place in lower grades of primary school;
- were conducted in the context of reading/writing;
- were evaluated by means of questionnaires.

3.4.2.5. Students' age. Meta-analytic regression analyses for the continuous variable of students' grade level (from one to six) did not reveal any significant differences for interventions conducted with younger or older students, except for strategy use: studies conducted at lower grades of primary school led to significantly higher effect sizes ($B = -.11$, $p < .01$). When including students' age as a continuous variable within the analyses, motivational effect sizes significantly declined with increasing age ($B = -.96$, $p < .01$).

3.4.3. Relationship between study design-related factors and effect size

3.4.3.1. Assessment instruments. With regard to the planning of further research designs in the area of educational training studies, a closer inspection of the impact of the operationalization of the dependent variable on the effect size variability seems to be especially interesting. This is particularly interesting because other authors found a relationship between the type of assessment and the magnitude of training effects in educational research (see e.g. Dochy, Segers, & Buehl, 1999; Dochy et al., 2003). In our meta-analysis, significant differences between effect sizes due to the different assessment instruments that researchers had used were found for the overall measurement ($Q_b = 13.98$, $p < .01$), students' strategy use ($Q_b = 10.45$, $p < .05$), as well as for motivational outcomes ($Q_b = 7.32$, $p < .05$). Over all outcome measurements together, effect sizes were highest when students' outcomes of the pre-post-evaluation of the intervention were assessed by means of a questionnaire. Moderate effects were found if the assessment instruments were task tests, as well as for the category of others, including thinking aloud tasks, observation, etc. Assessing students' outcomes with simulation tasks or multiple-choice tests revealed the lowest effect sizes. The analyses of the strategy use data demonstrated a similar picture: the category of others, as well as the questionnaires as assessment instruments, led to the highest effects; followed by task tests and simulation tasks, which led to moderate effects. The lowest effects were found when using multiple-choice tests. Regarding motivational outcomes, effect sizes were significantly higher when the assessment instrument was a questionnaire, and only moderate for task tests or other assessment methods (see Table 15).

3.4.3.2. Cross-comparison assessment instrument—outcome category. Cross-comparisons between the type of assessment instrument that the researchers of the primary studies had used and the outcome category revealed significant relationships between these two variables ($\chi^2 = 142.88$, $p < .01$). While academic performance was basically assessed by means of task tests, strategy use und motivational outcomes were mainly registered by use of questionnaires. Students' use of strategies was also measured with task tests, but motivation was almost only measured with questionnaires (38 effect sizes out of 48 measuring motivational outcomes in total).

Table 15
Mean effect sizes grouped according to the type of assessment instrument

Mean ES (S.E.)	All dependent variables*	Academic performance overall	Reading/ writing performance	Mathematics performance	Other performance	Strategy use*	Motivational outcomes
Task	.69 (.04)	.69 (.07)	.46 (.08)	.97 (.14)	.66 (.10)	.70 (.06)	.43 (.44), $n = 2$
Questionnaire	.86 (.06)	–	–	–	–	.81 (.08)	.87 (.09)
Multiple choice test	.41 (.14)	.35 (.26)	.35 (.24)	.57 (.61), $n = 1$	–	.45 (.14)	–
Simulation task	.58 (.08)	.55 (.13)	.39 (.11)	1.32 (.37), $n = 2$	.66 (.51), $n = 1$	.61 (.09)	–
Others	.66 (.09)	.57 (.17)	.56 (.15)	–	.48 (.31), $n = 2$	.95 (.12)	.31 (.19)
Random effects variance component, v	.20	.26	.15	.36	.17	.14	.27

* Significant differences between categories.

4. Discussion

4.1. First research question: summary of main effects

This meta-analysis examined the effectiveness of self-regulated learning interventions on primary school students' academic performance, strategy use, and motivation. Moreover, it investigated the effect of the different training characteristics on the effectiveness of the intervention. With regard to our first research question, the results of this meta-analysis have shown that self-regulated learning training programmes have a positive effect on learning outcomes, strategy use, and motivation, even for primary school children: the analysis – based on 263 effect sizes from 48 studies – reveals a weighted average effect size of .69. This includes the effects on academic performance, cognitive and metacognitive strategy use, as well as motivational aspects. To get a more detailed impression, the grouped summaries are .62 for academic performance, .73 for cognitive and metacognitive strategy use, and .76 for motivation. Thus, the effect sizes for self-regulation trainings found in this synthesis can be considered as relatively high. In addition to this, it seems to be interesting to compare these findings against other results in this field to get an idea of the effects of intervention in an educational setting. Sipe and Curlette (1997) conducted a meta-synthesis on 103 meta-analyses that investigated the effects of educational intervention, published from 1984 to 1993, and incorporated more than 4000 primary studies in the analysis. They found an unweighted average effect size of .38, which they propose as the benchmark of effectiveness. This finding is concordant with the results of Hattie (1992), who aggregated the effects of 134 meta-analyses related to educational achievement, published between 1976 and 1985, and found a mean effect size of .40. Against this background, the overall mean effect size for all outcomes found in this meta-analysis can be regarded as relatively high; whereas the effects on academic achievement are – depending on the school subject context – rather inconsistent, the effects on motivation and strategy application, for cognitive as well as metacognitive strategies, are highest.

Therefore, the highest benefits from the analyzed interventions can be gained in mathematics performance, motivational outcomes, as well as the use of cognitive and metacognitive strategies. These findings are not concordant with the results of the meta-analysis conducted by Hattie et al. (1996), who found the highest effects of learning skills intervention on performance, and the lowest on motivation/affect and study skills. This discrepancy could be due to age differences, since their meta-analysis included studies conducted at all different stages of life – from preschool children to adults – but most of the studies were conducted with older students or adults. Our meta-analysis already showed distinctions in the effects of self-regulation training programmes at primary school age. These results revealed that young children benefit more in the area of strategy use and motivation than primary school students in higher grades do. Just like Hattie et al. (1996), we also found slightly greater effects on motivation than on strategy use. In our synthesis, however, the average effect size was higher for cognitive and metacognitive skills than for academic performance, whereas academic performance attained the highest effect in the meta-analysis of Hattie et al. (1996). Yet, the effects on performance are hard to compare as, in this analysis, we found extremely variable effect sizes for the different academic fields (higher effects for mathematics than for reading and writing).

4.2. Second research question: drawing inferences from the results

With regard to our second research question, the results of the categorical comparisons suggest that different training characteristics lead to greater effects depending on the academic context. Several characteristics of training interventions could have been located that made interventions more effective than others (see Table 16).

4.2.1. Impact of treatment content-related factors on training success

4.2.1.1. Theoretical background. The summary of the training characteristics which made interventions most effective has demonstrated that interventions, which were based on social-cognitive theory or a combination of social-cognitive and metacognitive theories, led to the highest effect sizes, while interventions which were based on motivational theories reached only low effects. No significant differences were found for motivational outcomes. Social cognitive theory takes

Table 16
Overview of factors that make intervention programmes most effective

Treatment content-related factors	Training context-related factors
Social-cognitive theoretical background	Context of mathematics or reading/writing
Not only instruction of cognitive strategies, but different types of strategies	Directed by researchers
Instruction of planning strategies	Younger primary school students
Knowledge about strategies and benefits of strategy use	
Feedback and action control strategies	
No cooperative learning without explicit instruction and careful implementation	

into account an interaction of behaviour, cognition and other personal as well as environmental factors, influencing each other bidirectionally. Hence, learners are seen as both products and producers of their environment (Bandura, 1989) and are therefore considered as active participants in the learning process, in need of social support. Within the social-cognitive perspective, social factors play a significant role in cognitive development, which might be best suited to young children's learning. In comparison, metacognitive theories are more focused on cognitive features, also supposing that metacognition develops only at higher ages (Paris & Newman, 1990; Zimmerman, 1990). Theories focusing on motivation might not be applied here, since the interventions addressed the issue of motivation as only one subpart of the construct of self-regulated learning.

4.2.1.2. Type of strategies. Moreover, summing up the most effective training characteristics has revealed that interventions should be integrative and consider various different aspects of learning, including metacognitive and motivational aspects. Interventions with a mainly cognitive focus reached only low effects. The highest effects were found for interventions that combined the instruction of different types of strategies. This is in line with the results of several primary studies that tested different types of intervention including different types of strategies against each other (e.g., Desoete, Roeyers, & De Clercq, 2003; Kernaghan & Woloshyn, 1995; Schunk & Swartz, 1993; Souvignier & Mokhlesgerami, 2006). This result also supports the theoretical trend of recent models of self-regulated learning which advocate the consideration not only of cognitive and metacognitive, but also of motivational factors when investigating self-regulated learning (Boekaerts & Corno, 2005; Pintrich, 1999).

4.2.1.3. Type of metacognitive reflection. Besides the instruction of metacognitive strategies, students should be provided with knowledge about strategy application and its benefits, since the highest effect sizes were found for interventions which provided students' with both knowledge about strategies and illustrated the benefits of applying the trained strategies, or additionally also stimulated metacognitive reasoning. This is in line with research on strategy instruction having shown that learners need to be motivated to use strategies—they need the *skill* and the *will* to engage in self-regulated learning (see McCombs & Marzano, 1990).

4.2.1.4. Type of motivational strategies. Furthermore, most effective training programmes provided students with feedback about their (strategic) learning. In addition, the instruction of action control strategies positively influenced students' strategy use. This is related to the strategies of metacognitive reflection, and might be the most efficient because it is very close to the concrete learning content and strategy use. This is in line with most of more recent models on self-regulated learning, which are including these different aspects (Boekaerts & Corno, 2005; Puustinen & Pulkkinen, 2001). In contrast, causal attribution strategies aim to develop attribution patterns for success and failure, which are conducive to fostering the motivation to learn. These attribution patterns are dependent on students' attitudes towards learning as well as on their self-efficacy, which are both not easy to change within a short training period—and did not lead to higher training effects.

4.2.1.5. Group work. Surprisingly, effect sizes were significantly higher for interventions that did not train students by means of group work than for those that did, while in the mean time, there is now enough research showing that it can make learning more efficient and improve learning motivation (e.g., Guthrie et al., 1998; Johnson, Johnson, & Stanne, 2000; Slavin, 1996). Even very young students were found to benefit from group work (e.g., Whitebread, 2007). Several meta-analyses investigated this method and revealed positive effects: Lou et al. (1996) conducted a meta-analysis to compare cooperatively structured within-class grouping versus whole class instruction and found a small positive effect of group work on student achievement. In addition, they identified conditions under which group work becomes more effective, including structures of cooperative outcome interdependence, small groups rather than large groups, as well as teacher training and experience with small group instructional strategies. Abrami et al. (1995) found similar results when conducting a meta-analysis on cooperative learning with computer technology: the effects of group work on students' achievement were significantly enhanced when students had group work experience or instruction, and when specific group learning strategies were employed.

In the studies included in this meta-analysis, we found only very little information about the implementation of group work in the learning setting. Since cooperative learning was not the main topic of the interventions, little is known about how teachers or trainers introduced group work into the classroom. We also did not find any information about the experiences of students with group work, and whether they received any instruction about working in groups. As it is obvious that the positive effects of group work can only surface if students know rules about how to behave when working in groups, it would not be enough to let students sit around a table in small groups without providing them with any systematic instruction. Hence, a possible reason for the negative effect of group work on training effects at primary school level might be that students were not used to working in groups and did not receive enough instruction about cooperative learning.

4.2.1.6. Correlations between group work and other variables. To examine possible moderators for the negative impact of group work on the effect sizes, correlations were conducted between group work and other variables. Interventions that used group work as a training method were mainly based on motivational theories, instructing all kinds of cognitive strategies, did not provide students with strategic knowledge and emphasized the benefits of using these strategies less; they included more instruction of action control and causal attribution strategies, but less feedback, and lasted longer than interventions without group work. In addition, they were mainly conducted in the context of other subjects than mathematics or reading/writing. Since meta-analytic ANOVAs were conducted separately for each potential moderator variable, it was not possible to investigate the impact of cooperative learning when holding all other potential moderators constant. The negative impact of group work on the efficacy of training programmes might therefore be traced back to other factors; e.g. to the fact that those interventions using group work also focused on the instruction of cognitive strategies, which lead to lower effect sizes.

4.2.2. Impact of training context-related factors on training success

4.2.2.1. School subject. The highest effects on academic performance could be gained by interventions that took place in the context of mathematics, followed by reading/writing, lastly by those which were conducted within the scope of other school subjects; a similar picture occurred when regarding motivational outcomes, but no differences were found between the school subjects concerning the effects of strategy use. This is in line with the results from Wolters and Pintrich (1998), assuming that although there might be variation between subject areas, the relations between motivation and cognition seems to be stable across the different subjects. However, they found that mathematics was judged as more defined and static by the teachers, while science and language arts were described as more open and dynamic (Wolters & Pintrich, 1998). Following their reasoning, self-regulated learning should be easier to integrate in science and language arts classrooms, as these subjects are more flexible and open for students' activities. Contrary, our results indicate that promoting self-regulated learning raises academic performance more in a well-structured subject than in a rather open field. Wolters and Pintrich (1998) also reported that students tend to view mathematics as more important, useful, and interesting than language arts or social studies, which could also be an explanation for students' potentially higher engagement in mathematics than in reading and writing, and higher effect sizes measuring motivation of students following the training programmes.

4.2.2.2. Duration of intervention. Investigations of the length of interventions as a possible moderator for training effectiveness did not reveal a significant impact, except for the category of other performance. For this outcome category, effect sizes increased with a decreasing number of months. Hattie et al. (1996) also found a correlation between programmes shorter than 1 month and the effect sizes. However, in our meta-analysis, the impact of intervention length cannot be generalized to the other outcome categories.

4.2.2.3. Implementation of the programme. The summary of training characteristics shows that self-regulation training is being increasingly implemented by regular classroom teachers. Many authors have come up with theoretically based advantages of teacher-direction, as these serve an important role in the arrangement of the learning environment (see e.g., Perry & VandeKamp, 2000; Rozendaal, Minnaert, & Boekaerts, 2005). Nevertheless, the results of this review give evidence that students benefit more if researchers introduce strategies instead of their regular teachers. Only the outcomes concerning academic performance in mathematics and motivational outcomes were not concerned by the direction of the intervention. These findings go along with those of Hattie et al. (1996), who also discovered higher effects for researcher-directed interventions across all outcomes. Though these results are plausible since researchers developed the interventions themselves, they are not promising for implementing self-regulated learning training in everyday school life. Additional investigation on behalf of the teachers is needed to examine the implementation of training via regular classroom teachers in detail and to find the causes of the inferiority of teacher-directed intervention. Some authors of the primary studies report, for example that low training effects could result from the fact that teachers did not manage to implement the training contents in the classroom, although the training programme itself might have been effective. Unfortunately, primary studies did not report enough details about teachers' training to allow the inclusion of these factors into the meta-analysis.

4.2.2.4. Age of students. In addition to the main finding that, even at primary school age, students can profit from self-regulation intervention, the moderator analysis of the two different age groups suggests that even very young students (grade one through three) can acquire self-regulation competence efficiently. This result is similar to the finding of Hattie et al. (1996), who showed that even younger students benefit more from study skills intervention than older students and adults. Nevertheless, there are differences in the way the intervention effects arise: younger students show greater effects in motivational aspects, which ties in with the fact that younger children are already motivated to learn when they arrive at school—a fact that declines during schooling (e.g., Helmke, 1993; Krapp, 1998). They also achieve greater effects concerning the use of strategies than students in the upper grades of primary school. Some of the included primary studies tested their intervention for different age groups at primary school and found similar results (e.g., Ashman & Conway, 1993; Hohn & Frey, 2002). This could be because older students already command a strategy repertoire which is harder to change, while young students are more open to acquiring new strategies. However, these findings did not have an impact on the effects of the interventions regarding the academic performance of students.

4.2.3. Impact of study design-related factors on training success

4.2.3.1. Assessment instrument. For most of the outcome categories, effect sizes were highest for studies that evaluated the training effect by means of questionnaires. However, this type of assessment instrument is sometimes problematic: investigations of questionnaires measuring self-regulation competence revealed only low correlations between different instruments (Spörer & Brunstein, 2006; Veenman, 2005) as well as between questionnaire scales and achievement outcomes (Artelt, 2000; Veenman, 2005), leading to doubt if questionnaires can really assess self-regulated learning competences.

4.2.3.2. Cross-comparison assessment instrument—outcome category. Significant cross-comparisons revealed that in the primary studies included in this meta-analysis academic performance was basically assessed by means of a task tests, and strategy use und motivational outcomes were mainly registered by the use of questionnaires.

4.2.4. Summary of what makes intervention programmes most effective

Summarizing the most effective characteristics of interventions yields that a training programme should be based on social-cognitive theories, should train cognitive (especially elaboration and problem solving strategies), metacognitive (especially planning strategies), and motivational strategies (especially feedback), and provide knowledge about strategy use and about its benefit. Regarding the negative impact of group work that we found in this analysis, programme developers should especially emphasize the implementation of group work properly. Primary school students might not yet dispose of the competencies to work efficiently in groups and would still need instructions about cooperation. Researchers and trainers should therefore assure the instruction of group work strategies before and during using this method.

Factors related to the training context are often not changeable; therefore, it is not possible to conclude that teachers should not conduct training programmes, or that training should only take place in lower grades of primary schools. However, it might be helpful to keep in mind that several unanswered questions concerning the implementation of training programmes by teachers remain that require further investigation. In the same manner, further research should study the differences of instructing self-regulated learning to younger and older students in order to improve interventions and to make them suitable for the different needs of students at different ages.

Concerning the study design, we investigated the impact of different types of assessment instruments. An important finding is the large amount of questionnaires that are used to assess strategy use and motivation. Recent research on assessing self-regulated learning revealed the difficulty of questionnaires as they often lack in validity (e.g., Spörer & Brunstein, 2006; Veenman et al., 2006). Hence, further research should conduct evaluations of intervention programmes by means of multi-method analyses—especially for strategy use and motivation.

4.3. Limitations of the findings

Despite all practical implications on future research concerning intervention structuring and study planning, the interpretation of these results is subject to several limitations: firstly, we included only studies conducted at the primary school level in the synthesis. Therefore, the results cannot be generalized to intervention with older students. Since the impact of students' age as a moderator implies differences in the effectiveness of intervention concerning the age, further research should compare the usefulness of training characteristics in relation to the age of the students in more detail. Secondly, this analysis excluded study samples consisting of students with learning disabilities. However, for these students, facilitating learning would be even more necessary. Whereas Hattie et al. (1996) reported few benefits for low-ability students, a meta-analysis of 78 intervention studies conducted with students with learning disabilities (Swanson, Carson, & Saches-Lee, 1996) revealed a mean effect size of .85. Separated analyses of intervention conducted with learning disabled students could give insight into the similarities and differences for both groups of learners, with and without learning disabilities. Third, besides generalisation limitations relating to the study sample, the type of intervention was also restricted, as we did not include computerized intervention in the analysis. However, this sort of training takes place more and more often (Boekaerts & Corno, 2005) since research has indicated that computer-based learning environments require the learner to take more responsibility for the learning process (Schunk & Zimmerman, 1998). Further analyses should integrate this type of intervention in order to compare both of them. Future research should investigate the impact of instructional characteristics of computer-based learning instruction in promoting self-regulated learning.

4.4. Implications for further research

The above-mentioned limitations reveal a need for further synthesis in this field in order to broaden the options for generalisation. Another implication for research yields from the result that the learning environment seems to influence the effectiveness of an intervention. Very recent research already includes aspects of the learning environment while investigating self-regulated learning at school. Instead of examining single components of classroom arrangements, recent studies focus increasingly on the learning process as a whole in order to allow for the complexity of learning and instruction (De Corte, Verschaffel, Entwistle, & van Merrienboer, 2003). Further research should focus more on the learning environment, which obviously does have a great impact on the self-regulation of learning. This aspect implies that the teacher as a trainer is included more in the investigation. Analyses of how teachers can be trained are needed to fill the knowledge gap of implementing training programmes by teachers in the classroom. The focus on the learner must be expanded by the impact of teacher behaviour on the learning process. Teachers play a significant role in the promotion of self-regulated learning because they can function as multipliers while conducting direct student training programmes might be less economic (Perels, Otto, Schmitz, & Bruder, 2007). Further investigations are needed on how teachers can be adequately prepared for successful implementation of self-regulated learning instruction in the classroom (see Van Hout-Wolters et al., 2002). With regard to the implementation, the negative effects of group work as well as of teacher-directed interventions lead to the assumption that there is a need of investigating how the implementation of these training programmes in the real classroom can work successfully. Why are teachers not instructing self-regulated learning strategies as effectively as researchers are? Are they not willing to do so because of a lack of commitment? Alternatively, do they lack knowledge about how to enhance self-regulated learning (see e.g., Veenman, Kenter, & Post, 2000; Waeytens et al., 2002)? Would they need more support with the implementation in the classroom (see Kline, Deshler, & Schumaker, 1992; Souvignier & Mokhlesgerami, 2006)? How could the instruction of teachers be improved to face these challenges? The same questions are valid for group work: what is the teachers' attitude towards group work? Do they have sufficient knowledge about what makes self-regulated learning effective? According to Butler (2002), teacher training should stress the connection between theory and practice, in order to support teachers to bring together the conceptual frameworks with their knowledge based on teaching (Bromme & Tillema, 1995). In line with De Corte (2000) we conclude that in order to manage such fundamental changes of classroom practice, a partnership between researchers and practitioners when implementing self-regulation training programmes is necessary to reach teachers' beliefs about learning and instruction successfully (De Corte, 2000).

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Appendix A

See Table 17.

Table 17
Summary of studies included in the meta-analysis

Author (publication year)	*N*	Outcome category (no. of effects per category)	No. of effects per study	Level	Direction of the training	School subject	Treatment	Number of sessions	Assessment instruments	Focus of theoretical background
Adey and Shayer (2001)	468	Cognitive strategies (1)	1	1	Teacher-directed	Social science/science	Metacognition	40	Problem-solving task	Metacognition
Ashman and Conway (1993)	40–46	Academic performance reading (2) Metacognitive strategies (3) Academic performance maths (1)	6	4–6	Teacher-directed	Mathematics	Cognition, metacognition	24	Problem-solving task Simulation of a task	Metacognition
Benito, Foley, Lewis, and Prescott (1993)	29	Academic performance reading (1) Academic performance science (1)	2	4	Teacher-directed	Social science	Metacognition	18	Problem-solving task Simulation of a task	Metacognition
Bornas and Servera (1992)	14	Academic performance reading (2) Academic performance maths (2); self-efficacy (1)	5	5	Self-directed	Mathematics	Metacognition	22	Problem-solving task	Metacognition
Brown, Pressley, Van Meter, and Schuder (1996)	60	Academic performance reading (3) Metacognitive strategies (1) Cognitive strategies (1)	5	2	Teacher-directed	Reading	Cognition, metacognition	40	Problem-solving task; simulation of a task Interview Thinking-aloud task	Social-constructivism
Cardelle Elawar (1992)	62–90	Academic performance maths (2) Academic performance overall (2)	4	6	Self-directed	Mathematics	Cognition, metacognition	20–30	Problem-solving task	Metacognition
Cardelle Elawar (1995)	90	Academic performance maths (1)	1	5	Teacher-directed	Mathematics	Cognition, metacognition	40	Problem-solving task	Metacognition
De Jager, Jansen, and Reezigt (2005)	140–191	Metacognitive strategies (2)	2	5	Teacher-directed	Reading	Metacognition	40	Questionnaire	Metacognition and social-constructivism
Desoete et al. (2003)	108	Cognitive strategies (2) Metacognitive strategies (2) Academic performance maths (1)	5	3	Self-directed	Mathematics	Cognition, metacognition	5	Problem-solving task	Metacognition

Table 17 (*Continued*)

Author (publication year)	*N*	Outcome category (no. of effects per category)	No. of effects per study	Level	Direction of the training	School subject	Treatment	Number of sessions	Assessment instruments	Focus of theoretical background
Fuchs et al. (2003a, 2003b)	128–131	Cognitive strategies (2) Metacognitive strategies (3) Self-efficacy (1)	6	3	Teacher-directed	Mathematics	Cognition, metacognition	32	Problem-solving task Interview Questionnaire	Social-constructivism
Guthrie et al. (1998)	90	Academic performance reading (4) Academic performance writing (1) Academic performance science (3) Academic performance overall (1) Cognitive strategies (4) Metacognitive strategies (1)	14	3–5	Teacher-directed	Science	Cognition, metacognition, motivation	40	Problem-solving task Simulation of a task Interview Others	Motivation
Guthrie et al. (2004)	267–333	Academic performance overall (2) Academic performance reading (4) Metacognitive strategies (2) Motivation (1)	9	3	Teacher-directed	Science	Cognition, metacognition, motivation	60	Problem-solving task Simulation of a task Questionnaire	Motivation
Hasselhorn and Maehler (1992)	20	Metacognitive strategies (1) Cognitive strategies (3)	4	3	Self-directed	Not specified	Cognition, metacognition	2	Problem-solving task	Metacognition
Hohn and Frey (2002)	62	Cognitive strategies (1)	1	3	Teacher-directed	Mathematics	Cognition, metacognition	4	Problem-solving task	Social-constructivism
Kernaghan and Woloshyn (1995)	24	Academic performance overall (2) Academic performance writing (1) Cognitive strategies (1)	4	1	Not specified	Writing	Cognition, metacognition	4	Problem-solving task Simulation of a task	Metacognition
Kettmann Klingner, Vaughn, and Schumm (1998)	141	Cognitive strategies (1)	1	4	Self-directed	Social science	Cognition	11	Problem-solving task	Social-constructivism
Klauer (1996a)	30	Cognitive strategies (1)	1	6	Self-directed	Science	Metacognition	6	Multiple choice test	Metacognition

Klauer (1996b)	82	Cognitive strategies (4)	4	6	Self-directed	Not specified	Cognition, metacognition	10	Problem-solving task Multiple choice test	Metacognition
Loranger, 1997	32	Academic performance overall (1)	1	4	Self-directed	Reading	Cognition, metacognition	8	Problem-solving task	Social-constructivism
Lucangeli, Galderisi, and Cornoldi (1995)	89	Academic performance overall (1) Attribution (2)	3	5	Teacher-directed	Reading	Cognition, metacognition	90	Simulation of a task Questionnaire	Metacognition
Mason (2004)	32	Self-efficacy (1) Motivation (1) Academic performance reading (1) Academic performance writing (3) Academic performance overall (4)	10	5	Self-directed	Social science	Cognition, metacognition	15	Problem-solving task Questionnaire	Social-constructivism
Schober and Ziegler (2001)	214	Metacognitive strategies (1) Attribution (1) Self-efficacy (1) Academic performance maths (1)	4	5	Self-directed	Mathematics	Cognition, motivation	10	Problem-solving task Questionnaire	Motivation
Schreblowski and Hasselhorn (2001)	57–60	Metacognitive strategies (1) Attribution (2) Academic performance reading (1) Academic performance overall (1)	5	5	Self-directed	Reading	Cognition, metacognition	19	Problem-solving task Questionnaire Multiple choice test	Social-constructivism
Schunk and Swartz (1993)	30	Academic performance writing (1) Self-efficacy (3) Cognitive strategies (1)	5	5	Self-directed	Writing	Cognition	20	Problem-solving task Questionnaire	Social-constructivism
Schunk (1994)	22	Metacognitive strategies (4) Academic performance maths (3) Self-efficacy (1)	8	4	Self-directed	Mathematics	Cognition, metacognition	7	Problem-solving task Questionnaire Simulation of a task	Social-constructivism
Souvignier and Mokhlesgerami (2006)	173–230	Metacognitive strategies (2) Cognitive strategies Motivation (2)	5	5	Teacher-directed	Reading	Cognition, metacognition, motivation	20	Problem-solving task (2) Multiple choice test Others (2)	Social-constructivism

Table 17 (*Continued*)

Author (publication year)	*N*	Outcome category (no. of effects per category)	No. of effects per study	Level	Direction of the training	School subject	Treatment	Number of sessions	Assessment instruments	Focus of theoretical background
Sovik, Heggberget, and Samuelstuen (1996)	16	Cognitive strategies (6) Academic performance writing (1)	7	4	Self-directed	Writing	Cognition, metacognition	6	Problem-solving task Others	Social-constructivism
Vauras, Kinnunen, and Rauhanummi (1999)	44	Academic performance maths (1) Cognitive strategies (1)	2	3	Self-directed	Mathematics	Metacognition	34	Problem-solving task	Metacognition and social-constructivism
Verschaffel et al. (1999)	222	Academic performance maths (2) Cognitive strategies (1) Metacognitive strategies (1) Motivation (1)	5	5	Teacher-directed	Mathematics	Metacognition	20	Problem-solving task Questionnaire Simulation of a task Multiple choice test	Social-constructivism
Williams et al. (2002)	106	Academic performance writing (2) Metacognitive strategies (5) Academic performance reading (2)	9	5	Teacher-directed	Reading	Metacognition	40	Problem-solving task Interview Multiple choice test	Metacognition

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