Metacognition Learning (2008) 3:231–264
DOI 10.1007/s11409-008-9029-x

Components of fostering self-regulated learning among students. A meta-analysis on intervention studies at primary and secondary school level

Charlotte Dignath · Gerhard Büttner

Received: 19 November 2007 / Accepted: 1 September 2008 /
Published online: 1 November 2008

Abstract Due to new standards in fostering life-long learning at school, research has increasingly dealt with the promotion of self-regulated learning, resulting in a large number of intervention studies conducted at primary and secondary school. The current study aimed at investigating the impact of various training characteristics on the training outcomes, regarding academic performance, strategy use and motivation of students. Two meta-analyses were conducted separately, one for primary and one for secondary school level to allow for comparisons between both school levels. The meta-analyses included 49 studies conducted with primary school students and 35 studies conducted with secondary school students; analyzing 357 effect sizes altogether. The potential effects of training characteristics were investigated by means of meta-analytic multiple regression analyses. The average effect size was 0.69. For both school levels, effect sizes were higher when the training was conducted by researchers instead of regular teachers. Moreover, interventions attained higher effects when conducted in the scope of mathematics than in reading/writing or other subjects. Self-regulated learning can be fostered effectively at both primary and secondary school level. However, the theoretical background on which the training programme is based, as well as the type of instructed strategy led to differential effects at both school levels.

Keywords Meta-analysis · Review · Self-regulated learning · Metacognition · Strategy training · Primary school · Secondary school

C. Dignath (✉)
University of Muenster, Institute of Psychology V, Fliednerstr. 21,
48149 Muenster, Germany
e-mail: charlotte.dignath@uni-muenster.de

G. Büttner
J.W. Goethe University of Frankfurt/ Main, Senckenberganlage 15/ HP 126,
60325 Frankfurt/ Main, Germany
e-mail: buettner@paed.psych.uni-frankfurt.de

Introduction

Self-regulated learning in the context of lifelong learning

Self-regulated learning represents a major topic in educational research and has had a large impact on research on learning and instruction for several decades (Winne 2005). As indicated by the European Framework of Life-long Learning (EU Council 2002), today's society requires students to be able to learn in a self-regulated way during and after schooling and throughout their entire working life. Consequently, interest in educational research on improving learning and making it more efficient has resulted in a high number of intervention studies aiming at fostering self-regulated learning. The results of studies that examined the effects of self-regulated learning are consistent regarding the general positive impact on academic achievement and learning motivation (e.g., Zimmerman and Bandura 1994; Zimmerman 2001). When studying the literature on how to promote self-regulated learning, it becomes obvious that there is still a gap in the research about how teachers can bring self-regulated learning into the classroom. Most studies report attempts to improve students' academic self-regulation, but only little information is available about supporting teachers in how to do so. In order to advise teachers on this, it is essential to know which components of promoting self-regulated learning have proven to be valuable. Thus, a closer look at the effectiveness of components of intervention studies seems reasonable before e.g., developing a training programme for teachers. As former reviews on the promotion of self-regulated learning and teaching efficiency have indicated differences in younger and older students acquiring self-regulated learning (e.g., Hattie et al. 1996; Seidel and Shavelson 2007), a closer look at the differences between primary and secondary school level seems necessary.

In the present review, we wanted to examine the impact of self-regulation strategy training programmes at primary and at secondary school level; i.e., the impact of training characteristics (e.g., on which theoretical background training programmes were developed, what kinds of strategies were trained, who delivered the training) and study features (e.g., assessment instruments, sample size) on training effectiveness was investigated. We studied the effects of training programmes aimed at increasing self-regulated learning on academic achievement (mathematics, reading/writing, and other subjects), cognitive and metacognitive strategy use, and motivational aspects.

Although self-regulated learning is proving to be a recently well studied issue, the concept is based on historical results from educational research (e.g. Piaget 1954; Vygotsky 1978; Bandura 1989). With the beginning of constructivist learning theories, the idea that students should take responsibility for their own learning and should play an active role in the learning process replaced instructional theories, which assigned a reactive rather than a proactive role to the learner (Zimmerman 2001). Based on this paradigm shift, theories about self-regulated learning have evolved. According to Paris and Paris (2001), research on self-regulated learning changed from a cognitive strategy-oriented focus in the 1970s to experimental investigations of various strategy conditions in the 1980s, focusing increasingly on metacognitive aspects of learning. In the 1990s, research finally highlighted strategy intervention in the classroom (Paris and Paris 2001). Only over the last few years have theories accounted for motivational and volitional components of learning and academic self-regulation (Boekaerts and Corno 2005).

Nowadays, a large variety of different theoretical conceptions of self-regulated learning exists, relating to "considerable confusion in the literature with respect to the critical attributes of self-regulation, its key components, and related constructs… [and] there are almost as many definitions and conceptions of self-regulation as there are lines of research on the topic" (Zeidner et al. 2000, p 750). Definitions on self-regulated learning commonly view self-regulated students "as metacognitively, motivationally, and behaviourally active participants in their own learning process" (Zimmerman 1986), who "self-generate thoughts, feelings, and actions to attain their learning goals" (Zimmerman 2001). Boekaerts (1999) distinguishes three areas of psychological functioning in which self-regulated learning can appear: cognition, metacognition, and motivation/affect. Cognition concerns itself with the different cognitive strategies, applied to learn and perform a task, that refer to information processing. Metacognitive strategies are used to control and regulate cognition. Motivation and affect concern themselves with all motivational beliefs about oneself related to a task, such as self-efficacy beliefs, interest, or affective reactions to oneself and the task.

The effectiveness of promoting self-regulated learning

Despite the large amount of research on fostering self-regulated learning among students, some unanswered questions still remain. Weinstein et al. (2000) formulated some questions that should be addressed during further research: "What are the precursors of effective strategy use? How can we facilitate the development of these skills at differing ages? What can we do to help teachers incorporate learning-to-learn activities into their classroom teaching?" (Weinstein et al. 2000, p. 744). Meta-analyses should be an appropriate way to give an overview of the field of research, and additionally increase the statistical power of the primary studies (Becker 1988).

Former meta-analyses already reviewed training programmes that were developed to foster effective learning at school in order to examine the effectiveness of different training characteristics. Hattie et al. (1996) analysed the impact of diverse training characteristics of interventions to foster study skills for all possible age groups—from kindergarten through to adulthood. They compared 51 interventions already published by 1992 that aimed at enhancing students' learning by improving their use of study skills. This analysis included programmes that 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 situated in a context, and when fostering a high amount of student activity and metacognitive awareness. Since the theories of research on self-regulated learning of the last decade have "evolved due to new research findings and cross-fertilization of ideas" (Zimmerman 2001), a further meta-analysis that includes recent studies published within the last 15 years, could reflect the current status of research. Theoretical understanding of promoting self-regulated learning among students has been elaborated on during the past decade (Zimmerman 2001), resulting in new programmes on self-regulated learning (Boekaerts et al. 2000; Zimmerman 2001). Also Hattie et al. (1996) stated in their article that "at the present time, however, attempts at modelling intervention programmes for enhanced learning lack broadly based supportive data. Not to put too fine a point on it, theory may have leapt ahead of the evidence" (Hattie et al. 1996; p. 103). Therefore, our aim was to conduct a meta-analysis that includes recent primary studies which already reflect and account for theories on self-regulated learning that have emerged in the last decade in order to tie in with the valuable results of the review by Hattie et al. (1996). Because our research aim was to investigate the promotion of self-regulated learning in primary and secondary classrooms, we wanted to investigate interventions, which were integrated in the normal teaching context, while Hattie et al. (1996) only "reviewed studies that aimed at improving student learning by intervention outside the normal teaching context" (Hattie et al. 1996, p. 99). As Paris and Paris (2001) stated, in the 1990s research studies were conducted that aimed at including instruction on self-regulated learning in the classroom. These recent studies should be included in the investigation as well. For the same reason, we concentrated on the analysis of studies conducted with primary or lower secondary school students instead of including learners from all age groups, and we did not include studies that were conducted with particularly low or high achieving students. While Hattie et al. (1996) reviewed studies of which the "majority […] was implemented in universities wherein students self-selected to participate" and "was conducted for atypical students (the low, high, and underachievers)" (Hattie et al. 1996, p. 112), our investigation might reveal new results as it is based on a different sample. Therefore, a new meta-analysis seems indicative of our purpose.

We did the first meta-analysis with training studies conducted at primary school to analyze the research of the last decade that has dealt with promoting self-regulated learning amongst primary school students (Dignath et al. 2008), revealing that self-regulated learning can be taught effectively as early as primary school age. In line with these results, Hattie et al. (1996) had found higher effect sizes for primary and lower secondary school than for older school levels or university. One noticeable result of both meta-analyses (see Dignath et al. 2008 and Hattie et al. 1996) was the superiority of researcher-directed interventions over those interventions directed by teachers. Due to differences in teacher education among primary and secondary school teachers, as well as different developmental theories on students' capacity for academic self-regulation, it seems interesting to compare this effect with studies conducted with secondary school students. Another result that motivated us to examine intervention studies at secondary school level was higher effect sizes for interventions among younger rather than older primary school students. If interventions are more effective when conducted with first to third grade students than for fourth to sixth graders, the question arises whether secondary school students are even harder to train effectively, or whether they, due to their developmental advantage, achieve even better than younger students.

As we are interested in fostering self-regulated learning among primary and secondary school students, a closer look at the particularities determining the effectiveness of interventions for the different age groups would be interesting and might give new insights into the differences in acquiring self-regulation strategies at different ages. The present article will therefore analyze the effectiveness of self-regulation interventions of the last decade among students at primary and secondary school, and shall allow comparing the effectiveness of interventions between primary and secondary school students.

With regard to the method, this meta-analysis should correct for possible relationships among the training characteristics under investigation: Investigating the potential moderator effects one by one can lead to inaccurate results in the case that particular training features might appear together, leading to different effects under various circumstances; e.g. two training characteristics might be correlated, showing an effect for one characteristic, which in fact results from the effect of the second characteristic. To control for these co-occurrences, this present meta-analysis integrates the whole set of possible moderators simultaneously into one analysis.

Potential moderator effects

The following questions will be investigated by analyzing the moderator effects of training characteristics:

Are there age differences in acquiring self-regulation competence? According to the suggestions resulting from most of the research from the 1980s and 1990s, children in the elementary grades and younger should have difficulties in applying cognitive and metacognitive strategies (Paris and Newman 1990; Zimmerman 1990). One would therefore assume differences in acquiring different components of self-regulated learning between younger and older students. There are some research results on cognitive and metacognitive strategies indicating that independent strategy use increases with age (e.g., Waters and Andreassen 1983). In particular, the metacognitive development has already been investigated from the 1970s onwards, indicating age differences in metacognitive knowledge and skills. Alexander et al. (1995) conducted a literature review on studies conducted in the 1970s and 1980s that examined developmental differences of metacognition in gifted children, also providing hints on developmental differences in non-gifted children: They divided their analyses into three areas: 1) Children's declarative metacognitive knowledge, 2) their cognitive monitoring, and 3) their regulation of strategy use. (1) Developmental changes in declarative knowledge were found not only between earlier and later elementary school grades, but also between later elementary and earlier secondary school grades (see Alexander et al. 1995). (2) With regard to cognitive monitoring, children already start developing monitoring skills by the age of 4–5 (Cultice et al. 1983), but only use them later, not before the age of 11–12 (Veenman and Spaans 2005). Only a few studies deal with developmental differences in cognitive monitoring, indicating that due to the high cognitive demands, monitoring is even difficult for adults (Alexander et al. 1995). (3) Concerning the regulation of strategy use, children differed in complexity of strategy use from earlier to later elementary school grades (Robinson and Kingsley 1977). Moreover, according to Alexander and her colleagues (1995), students already acquire maths strategies during the early primary school years, while text comprehension strategies are only used in later elementary school years.

Within the last couple of years, more and more research has been done about young students' self-regulation, giving empirical support to the presumption that young children already can and do engage in activities of self-regulating their learning (e.g. Biemiller et al. 1998; Bronson 2000; Perry et al. 2004; Perry et al. 2002; Whitebread 1999). According to Schneider and Sodian (1997), the use of "classical" strategies as rehearsal, organization and elaboration is rarely found in children younger than the age of six. However, recent research shows strategic competence in very young children, so that a "barrier theory" assuming that children around the age of 6 would shift from not using to using metacognitive strategies is no longer tenable (Schneider and Sodian 1997). Empirical studies provide evidence for a developmental progression of children's competent strategy use from kindergarten to elementary school age (e.g., Flavell et al. 1993). The development of children's metacognition goes on during schooling from 5 to 16 years: children increasingly become aware of their thinking—meaning their *own personal knowledge state*, the *characteristics of tasks* that have an impact on learning, as well as their *own strategies* to monitor their learning (Paris and Winograd 1999). Sophisticated strategy use progresses further during adolescence and early adulthood (Schneider and Sodian 1997).

Further research is required concerning age differences in the acquisition and instruction of self-regulatory skills (see e.g., Zeidner et al. 2000). Pressley et al. (2006) propose cross-sectional research by conducting interventions at different age levels to allow for insight into developmental changes in the effectiveness of interventions: Meta-analysis can provide insight into these changes in the effectiveness of interventions by combining individual studies of interventions conducted at different age levels.

Which type of strategy is most effective? Concerning the training contents, Hattie et al. (1996) found in their meta-analysis that unistructural interventions, in which students were taught cognitive strategies, such as mnemonic devices or graphic organisers, had the strongest effect on performance and a moderate effect on affect. Relational programmes, which trained a combination of metacognitive, cognitive, and motivation strategies, were effective for performance and highly effective for affect. Due to a small number of effect sizes, no effect sizes for measures of study skills are available (Hattie et al. 1996). In the meta-analysis conducted with primary school studies (Dignath et al. 2008), effect sizes were highest for training programmes that did not only instruct cognitive strategies, but rather a combination of various strategy types. Moreover, effect sizes were higher when the benefit of strategy use was emphasized, when students learned planning and action control strategies, and when feedback was provided.

With regard to the different types of strategies, Weinstein and Mayer (1986) distinguish between cognitive and metacognitive strategies: Cognitive strategies refer to the learners' cognitive processes during the process of encoding information while problem solving or text studying. Metacognitive strategies refer to the learners' knowledge of, and control over their own cognitive processes. Motivation strategies play a significant role by providing the learner with the will to use these strategies (McCombs and Marzano 1990). To get a more detailed picture of the effects of promoting the various strategies, analyses should investigate the impact of instruction of cognitive, metacognitive, or motivation strategies, as well as of more general metacognitive reflection.

Instruction of cognitive strategies Following Weinstein and Mayer (1986), the major categories of cognitive strategies are (1) *rehearsal strategies* such as copying or underlining, (2) *elaboration strategies* such as paraphrasing or summarizing, and (3) *organizational strategies* such as outlining or creating a hierarchy, as well as problem solving strategies (Mayer and Wittrock 1996).

Instruction of metacognitive strategies Schraw (1998) mentions three groups of metacognitive strategies: planning, monitoring, and evaluation. *Planning* involves the selection of appropriate strategies and the allocation of resources. *Monitoring* refers to checking one's comprehension and performance, e.g. by means of self-testing. *Evaluating* designates the judgement about the products and efficiency of one's learning, e.g. by re-evaluating one's goals and conclusions (Schraw 1998).

Promoting metacognitive reflection Several researchers (e.g., Butler 2002; Schraw 1998) emphasize the importance of understanding *how* to use strategies. Strategy training should integrate information about *how* to use several strategies, and about the *conditions* under which these strategies are most useful, and should illustrate the benefit of using them. Besides the instruction of several types of strategies, students should acquire knowledge about how, when, why, and where to apply these strategies (Veenman et al. 2006).

Instruction of motivation strategies Recent models additionally stress motivation as an important component in self-regulation processes (see, e.g. Boekaerts 1999; Pintrich and De Groot 1990; Pintrich 1999). According to McCombs and Marzano (1990), students need to have the *skill* and the *will* to self-regulate. Following these models, motivation therefore seems to have a high impact on the efficiency of learning. Pintrich (1999) mentions three motivational components that may be linked to the components of self-regulated learning: 1. an expectancy component, including students' beliefs about their ability to perform a task, 2. a value component, comprising students' goals and beliefs about the importance and interest of the task, and 3. an affective component, referring to students' emotional reactions to the task.

What is the influence of students' cooperative learning on training effects? Most studies investigating the influence of cooperative learning on self-regulation draw a favourable balance: students working in groups acquire higher learning motivation, work more independently, and achieve higher academic performance (e.g., Rojas-Drummond et al. 1998; Stevens and Slavin 1992). Despite this consensus about the positive impact of cooperative learning, it is still unclear whether the conditions under which cooperative learning have such a positive effect (Slavin 1996). There are only a few studies which compare interventions that allow for cooperative learning with those that do not (Slavin 1996; for comparison see e.g., Kramarski and Mevarech 2003). While these studies found positive effects for cooperative learning results, we found negative effect sizes for studies that reported the use of cooperative learning methods to foster self-regulated learning at primary school (Dignath et al. 2008).

How should instruction be delivered? When researching the literature on promoting learning strategies, one finds competing theories about how the intervention contents should be instructed (Pressley et al. 2006). Several researchers have criticised the gap between theoretical research and educational practice. Even intervention studies conducted in educational settings have to face the critique of lacking internal validity and therefore practical relevance in the classroom (De Corte 2000). As a consequence, intervention studies have been accomplished that cooperate with teachers during the implementation of training programmes in the classroom. Since these teacher-directed programmes have emerged only in the last few years, it seems interesting to compare teacher- with researcher-directed programmes.

Research Questions

The goal of this meta-analysis is to review intervention studies on self-regulated learning, and to investigate the following research questions:

1. Do primary and secondary school students benefit from interventions that aim to foster self-regulated learning and does one of both groups benefit more regarding performance, strategy use, or motivation?
2. Are there training characteristics which make intervention programmes especially effective, and which characteristics are these?
    a. Does it make a difference on which theoretical basis intervention programmes are developed?
    b. Is the instruction of cognitive, metacognitive, or motivational strategies more efficient?
    c. Are intervention programmes more successful when also promoting metacognitive reflection?
    d. Does it make a difference in the scope of which school subject the intervention takes place?
    e. Are interventions more successful when directed by researchers or by teachers?
    f. Does the duration of the intervention have an influence on its effectivity?
    g. Does the assessment instrument, which was applied for the evaluation of the intervention, have an impact on the effect sizes?
3. Do these training characteristics work in the same way at primary and secondary school level?

Methods

Data collection

Literature search

The literature search was carried out in the *PsycInfo* and *ERIC* online data bases as well as in the German online data base *Psyndex.* Forty-five words describing self-regulated learning and its components were selected for an all-inclusive search, in order to identify all relevant references of interventions that aimed at improving students' learning behaviour (Dickersin 1994). Based on the meta-analysis of Hattie et al. (1996), we used the following key words: *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.* Furthermore, according to the Hattie et al. (1996) review, the following criteria for including a study in the sample were applied:

a) The study had to be concerned with self-regulated learning
b) It had to be possible to compute effect sizes
c) It had to be some type of training
d) The outcome had to be performance, self-regulation strategy, or affect/motivation.

The search was restricted to studies conducted at primary and secondary school level by means of keywords like primary school, elementary school, junior high school etc. Finally, the search was limited to the publication years 1992 to 2006.

Eligibility criteria

1. *Time frame*: To follow up the meta-analysis of Hattie et al. (1996) on the effectiveness of study skills interventions including studies published until the year 1992, this review only includes studies published after this time in order to give subsequent information.
2. *Purpose of the study*: Studies focused on fostering self-regulated learning within a school context. Therefore, experimental laboratory settings were not included, and the intervention had to last more than one single session. The intention of the research was to support and promote self-regulated learning amongst students by means of direct strategy instruction in terms of an informed training programme (Brown et al. 1996). Interventions without any explicit strategy instruction, which aimed at fostering self-regulated learning, e.g., only by implementing cooperative learning arrangements in the classroom, were not included.
3. *Training contents*: Although the interventions do not obligatorily need to be named “self-regulated” they should aim at fostering self-regulated learning among students according to the definition of Schunk and Zimmerman (1998) stating that the self-regulation of learning refers to the impact of students' self-generated thoughts, feelings, and actions serving to strive for their own goals. In addition, primary studies have to include one or more components of academic self-regulation in their intervention. Following the model of Boekaerts (1999), these can be classified in the broader categories *cognitive, metacognitive*, or *motivational strategies*.

4. *Students' characteristics*: In order to be able to generalize the results to school learning, studies should be conducted with primary or secondary school students up to the tenth grade following American and most European School Systems. Grade numbers from different countries were adjusted so that grade 1 includes students at the age of 5 to 6, and grade 10 students at the age of 15 to 16. Participating students should not suffer from learning disabilities, but should be representative for the general school community.
5. *Research design*: For assuring a methodological standard, which allows meta-analytic statistical procedures, the studies had to be conducted with a pre-post control-group design to control for systematic pretest differences. In the case that pretest results were not reported, studies were only included if they had tested that there were no significant differences between the groups before the start of the intervention. Studies had to report the sample sizes, mean and standard deviations, or respective F-values, to compute effect sizes. The samples had to include at least ten students per group in order to assure that the effect size d is approximately normally distributed (Hedges and Olkin 1985). Only interventions that lasted for at least a minimum of 1 week were included to distinguish between interventions and one-time experiments (see Slavin 1996).
6. *Publication type*: Due to difficulties in obtaining unpublished papers, only studies published in peer-reviewed journals or as an ERIC document (conference papers) were included in the review.

Information coded from the studies

Outcome measures

Interventions fostering self-regulated learning and thus aiming at improving students' learning are supposed to have a direct influence on academic performance (see e.g. Paris and Paris 2001; Zimmerman and Bandura 1994). Therefore, all included primary studies evaluated interventions by assessing students' academic performance.

Besides, and especially if *several* components of self-regulated learning are trained, it is interesting to see how students improve in applying the trained strategies. As a consequence, most of the studies did not only report results from academic achievement, but also strategy use and motivation of the students. Thus, three outcome categories were operationally defined for this review: (1) academic performance, (2) use of/knowledge about cognitive and metacognitive strategies, and (3) motivation.

Based on the meta-analysis of Hattie et al. (1996), we grouped outcome measures into these three categories: those measuring students' strategy use, those assessing students' motivation and related affect, as well as those measuring students' academic performance. These three categories were again sub-divided into several sub-categories, which will be presented later.

Characteristics of intervention contents

A coding scheme was developed to ensure accuracy in the coding process, conducted by two different coders. Interrater agreement was determined by means of Cohen's Kappa, and was within acceptable bounds (ranging from 80% to 100%). Ratings of theoretical background categories were done collaboratively, and differences were resolved by discussion. Studies were coded for information about the participants, and the analysis procedure including available results, as well as for further training characteristics. The type of instructed strategies was coded based on the classification described earlier. Most of the interventions aimed at instructing (a) cognitive learning strategies to the students. These strategies have a direct impact on the information processing, and are mostly related to a certain discipline (Klieme et al. 2001), e.g. text comprehension strategies, or mathematical problem solving.

In addition, some of the interventions also include (b) metacognitive or (c) motivational aspects of strategy. More generally, (d) metacognitive reflection was coded to investigate the impact of providing students with strategic knowledge or knowledge about the benefit of strategy use. As recent literature on self-regulated learning also focuses on the characteristics of the learning environment that can contribute to effective learning by creating opportunities for students to self-regulate their learning (De Corte et al. 2004), interventions were also coded for (e) providing situations of group work.

Characteristics of implementation of interventions

Interventions were coded for the (f) school level at which the training took place. As most of the studies were conducted in countries where the first 6 years of schooling are called primary school, studies conducted within grade 1 through 6 were coded for primary school, and those conducted among students from grade 7 to 10 were coded for secondary school. Moreover, little is known about whether students acquire knowledge about learning more efficiently when taught by their regular teachers or by researchers from university who developed the intervention themselves. To fill this gap, interventions were coded for implementation by (g) regular teachers versus external researchers. To gain insight in the practicality of training, the (h) length of the intervention was also included as a potential moderator. Since not all studies provided information about the duration of the training in terms of the number of weeks or months, the number of training sessions was included into the analyses as a continuous variable.

Computation of effect sizes

The standardized mean differences to compare the effects of pre–post data

Effect sizes were calculated as standardized mean differences between treatment and control conditions (Hedges and Olkin 1985) for all outcome variables in each study. All effect sizes were transformed into a common metric. It was required that they all estimated the same treatment effect. The treatment effects were grouped into the categories *academic achievement*, *strategy use*, and *motivation*.

Intervention studies usually compare results across independent groups relative to the variability within the groups. All the included studies reported mean differences between a treatment and a control group. Therefore, the standardized mean difference (Hedges and Olkin 1985) is an appropriate estimator, according to the research question of this review. As studies using a single-group pretest–posttest design focus on change within a person relative to the variability of change scores, instead of the variability within groups, they examine different research questions and should not be combined. Studies using a single-group pretest–posttest design were therefore excluded from this review (e.g. Lipsey and Wilson 1993). (A further description of the computation of effect sizes can be found in the Appendix.)

When aggregating the effect sizes across the studies, it should be taken into account that the effect sizes from studies with different sample sizes do not estimate the treatment effect with the same precision. We therefore weighted the effect sizes of the studies by the inverse of their estimated sampling variance in order to give more weight to effect sizes resulting from larger samples, assuming that these effect sizes estimate the population parameter more precisely (Cooper and Hedges 1994; Hedges and Olkin 1985; Morris and DeShon 2002).

Dealing with statistically dependent data

As mentioned earlier, most of the studies evaluated the effectiveness of the training by means of several instruments measuring different constructs. In order not to compare "apples with oranges", effect sizes were analyzed separately, grouped according to the construct. This also reduced the probability of dependent effect sizes extracted from the same study (Gleser and Olkin 1994). However, there were still two sources of dependency amongst effect sizes: (1) some effect sizes came from the same sample and measured the same construct, e.g. when studies assessed the same construct with several instruments or did not report an overall value for a questionnaire but only subscales. (2) Some studies compared different treatments to the same control group.

1. To keep as much information in the analyses as possible, these effect sizes were aggregated per study and construct (see Slavin 1996). To account for dependency and to avoid studies with a larger number of outcome variables having a higher impact, the variances of the effect sizes were aggregated by dividing their sum by the square of numbers of effect sizes. Consequently, effect sizes extracted from the same study do not get a weight of more than one altogether.
2. In addition, several articles reported the results of different treatments compared to the same control group. When pooling effect sizes across studies, each treatment–control comparison counted as one observation, each delivering effect sizes from similar measures. These effect sizes resulting from different treatments were therefore not averaged. However, counting each dependent measure as a separate effect size gives too much weight to studies with a large number of treatment comparisons. The sample sizes of these control groups were therefore adjusted to the number of treatments, resulting in an adjusted inverse of variance for the weighting procedure.

Estimating a mean effect size

Effect sizes were combined across studies by using standard meta-analytic procedures (Lipsey and Wilson 2001) for every outcome category separately. Each effect size was weighted by the inverse of its variance (Cooper and Hedges 1994; Hedges and Olkin 1985; Morris and DeShon 2002) and an additional random variance component to account for heterogeneity amongst the effect sizes (Hedges and Pigott 2004).

Identifying potential moderator variables

Meta-analytic models: fixed, random and mixed effects models

The fixed effects model assumes that each study in the meta-analysis has the same underlying effect (Brockwell and Gordon 2001). A significant Q value, indicating heterogeneity amongst the effect sizes, leads to the assumption that the variability of the effect sizes does not result only from the sampling error within a study as assumed under a fixed effects model (Hedges and Olkin 1985). Rather, it seems appropriate to suppose that the observed effect sizes do not share a common population effect size, but have a study-level sampling error in addition to a subject-level sampling error associated with them (Lipsey and Wilson 2001). In contrast to the fixed effects model, the random effects model allows a variance in both the estimated and the true effect between the individual studies. Unless only little between-study variation is found, simulation studies show that random effects models outperform fixed effects models concerning the trueness of results due to substantial differences in standard error estimation (e.g., Berkey et al. 1998; Brockwell and Gordon 2001). Consequently, fixed effects models risk producing high Type I error rates if effect sizes are heterogeneous (e.g., Cohn and Becker 2003; Higgins and Thompson 2004). As we can assume substantial heterogeneity in the data, in this review random effects (between-study differences) were supposed to have an impact in addition to the impact of the moderators. Thus, a mixed model was applied which treats the between-study effect as random and the moderator effect as fixed. Following Overton (1998, p. 365), the mixed model defines the moderator variable in the context of $r_i = \beta_0 + C\beta_1 + \tau_i + e_i$ with the random effects variance component τ_i as a measure of the between-study heterogeneity.

Fitting meta-analytic models: the procedure of meta-regression

In order to incorporate multiple moderators in the same analysis, moderator analyses were conducted by means of multiple regression analysis for effect sizes (Hedges and Pigott 2004). A meta-regression investigates the impact of special training characteristics on the heterogeneity among results of multiple studies. In contrast to a standard weighted regression, in meta-regression the inverse variance is specified as the weight, the effect size as the dependent variable, and training characteristics as independent variables. The standard weighting procedure would assume weights to represent different numbers of subjects. Consequently, the significance testing of a standard weighted regression would be based on incorrect assumptions concerning the sample size (Lipsey and Wilson 2001). Therefore, the standard errors for the regression slopes must be corrected by dividing the usual standard errors by the square route of the mean-square residual (Higgins and Thompson 2004). In comparison to univariate multi-analytic ANOVAs, which might detect a significant difference between treatment X and treatment Y, other factors than the examined ones could account for the apparent differences, which are significantly different in studies of treatment X and Y (Slavin 1996). The meta-analytic regression integrates the whole group of potential moderators in the analysis and can consequently control for shared variance among training characteristics. In addition, the type I error rate, which can be inflated by conducting several univariate analyses, is controlled for. An Omnibus test is used to investigate whether the group of moderator variables is related to the effect sizes. The specification of the regression model is tested by the goodness-of-fit statistic Q with k–p degrees of freedom, where k is the number of studies and p is the number of entered moderators. In the mixed model the moderator variables do not explain all of the variation in the effect size parameters, but a study-specific random effect is assumed in addition to the within-study sampling error. Therefore, a residual variance component is computed to investigate the amount of residual variation over and above the sampling error variation (Hedges and Pigott 2004). The analyses are conducted with statistical procedures by Lipsey and Wilson (2001). The regression model is fitted by first including all potential moderators in the model. Most of the variables are dummy-coded into dichotomous variables to be included in the regression. Only the number of training sessions and the school grade remain continuous variables. Following backward elimination (see Heij et al. 2004), a parameter is removed from the model if the confidence interval amounts to zero. The model is refitted, and the elimination is repeated step-by-step until all remaining variables are significant (Viechtbauer 2006).

In order to identify any potential training characteristics, regression analyses are performed on each of the various outcomes.

Comparing primary and secondary school level

In addition to the impact of school level on the effectiveness of the training programmes, analyses should also reveal if the effect of moderators is different for primary or secondary school level. Thus, analyses are conducted for both school types separately. Differences between the school levels in size and direction of the effects will be reported.

Results

Descriptive analyses of the studies

After excluding studies, which did not meet the eligibility criteria, the literature search yielded 74 studies in which a treatment was compared against a control condition. These training evaluations contained a sample of 8,619[1] students overall. Three hundred fifty-seven effect sizes were extracted from the studies and grouped within the three outcome categories. One hundred thirty-six effect sizes described academic performance, 167 described cognitive and metacognitive strategy use, and 54 were concerned with motivational aspects.

Two hundred sixty-three effect sizes resulted from studies conducted at primary school and 94 effect sizes from secondary school interventions. At primary school, 102 effect sizes measured academic performance, 113 cognitive and metacognitive strategy use, and 48 measured motivational aspects. At secondary school, 34 effect sizes resulted from academic performance outcomes, 54 from cognitive and metacognitive strategy use, and six from motivational aspects.

Frequencies of training characteristics

A summary of the characteristics of the studies and effect sizes is given in Table 1. Most of the studies placed their theoretical focus on metacognition (39 studies) or social-cognitive learning theories (35 studies), whereas only nine studies were based on a motivational background. Fifty-five training programmes instructed cognitive strategies, 49 focused on metacognitive strategies, and 43 trained metacognitive reflection. Only 27 studies included the instruction of motivation strategies. Thirty-three studies used group work as an instruction method. Almost half of the interventions were conducted by researchers, and half by regular teachers. Twenty-eight interventions took place in the domain of mathematics, 26 programmes had a reading/writing context, and 20 programmes were conducted within other subjects. The number of training sessions ranged between 2 and 90 sessions per intervention, with around 20 sessions on average.

[1] Sum of all the treatment and control group samples throughout all the studies, while control group sample sizes were adjusted if several treatments were compared against the same control group.

Table 1 Summary of study and effect size characteristics

Variables	n=357 (effect sizes)	N=74 (studies)
School level	Primary school: 263	Primary school: 49
	Secondary school: 94	Secondary school: 25
Theoretical background	Metacognitive: 173	Metacognitive: 39
	Social-cognitive:163	Social-cognitive: 35
	Motivational: 54	Motivational: 9
Instruction of cognitive strategies	240	55
Instruction of metacognitive strategies	238	49
Instruction of motivation strategies	153	27
Promotion of metacognitive reflection	207	43
Direction by	Teachers: 179	Teachers: 35
	Researchers: 178	Researchers: 39
School subject	Mathematics: 132	Mathematics: 28
	Reading/writing: 142	Reading/writing: 26
	Others: 83	Others: 20
Duration of the intervention	M=2.1 (SD=1.19)	
Assessment instrument	Performance test: 150	
	Questionnaire: 90	
	Simulation task: 78	
	Multiple choice:31	
	Interview: 3	
Sample size	M=98.33 (SD=116.03)	

Distribution of training characteristics

An inspection of the distribution of the effect sizes revealed statistical outliers that were more than two standard deviations above or below the mean effect size. Statistical outliers can exert an exceedingly strong influence on the results and were therefore eliminated from the analyses following a procedure suggested by Lipsey and Wilson 2001. Figure 1 presents the distribution of effect sizes grouped according to the various outcome categories and the school level (Table 2).

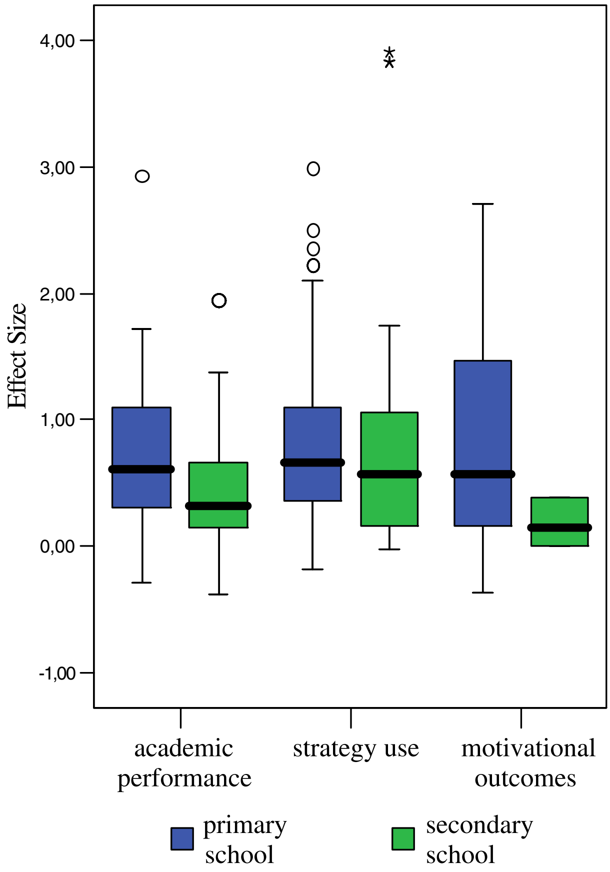
Inferential analyses of the studies

The overall effect of interventions

On the basis of the 357 effect-size estimates an overall average effect size was computed. Following the APA guidelines, weighted and unweighted mean effect sizes are reported (see Becker 2005): The unweighted average was 0.73 and the weighted overall, underlying a random effects model, was 0.69 and was significantly larger than zero (Z=27.30, p<0.01).

A separate inspection of the primary and secondary school data revealed a weighted overall mean effect size of 0.68 for primary school and 0.71 for secondary school. Considering the averaged effect sizes for the different outcome categories separately for both school levels displayed a mean effect size of 0.61 for the overall measure of academic performance at primary school and 0.54 at secondary school. Mathematics performance yielded a mean effect size of 0.96 at primary and 0.23 at secondary school. For reading performance, the effect size average was 0.44 at primary and 0.92 at secondary school, as well as 0.64 at primary school for academic performance in subjects other than mathematics

Fig. 1 Distribution of effect sizes grouped for primary and secondary school



and reading, while it was 0.05 at secondary school. However, it should be taken into consideration that the latter mean effect size was only based on six single effect sizes when interpreting this result. The mean effect size for strategy use was 0.72 at primary school and 0.88 at secondary school. We found a mean effect size for motivation outcomes at primary

Table 2 Average effect sizes grouped according to outcomes

	Primary school mean ES (SE)	−95% CI	+95% CI	Secondary school mean ES (SE)	−95% CI	+95% CI
All dependent variables	0.68 (0.03) n=263	0.63	0.74	0.71 (0.05) n=94	0.61	0.81
Academic performance overall	0.61 (0.05) n=102	0.52	0.70	0.54 (0.11) n=34	0.31	0.76
Academic performance mathematics	0.96 (0.13) n=25	0.71	1.21	0.23 (0.08) n=12	0.07	0.38
Academic performance reading/writing	0.44 (0.06) n=55	0.34	0.55	0.92 (0.20) n=16	0.52	1.31
Academic performance other subjects	0.64 (0.09) n=22	0.46	0.83	0.05 (0.15) n=6	−0.25	0.36
Strategy use	0.72 (0.04) n=113	0.64	0.79	0.88 (0.06) n=54	0.76	1.00
Motivation	0.75 (0.09) n=48	0.57	0.92	0.17 (0.06) n=6 (N=1)	0.04	0.31

n Indicating number of effect sizes; N indicating number of studies school of 0.75 and at secondary school of 0.17. Again, this last result is only based on six effect sizes and should therefore be interpreted carefully.

Due to heterogeneity among the effect sizes (Q statistics to test for homogeneity were significant for the empty model of all outcome categories), the average weighted effect sizes should only be understood as a description of the mean of the observed effect sizes and not as estimates of a population parameter (Shadish and Haddock 1994).

Relationship between moderators and effect sizes

A meta-analytic weighted multiple regression analysis was performed using an SPSS macro (METAREG.SPS) provided by Lipsey and Wilson (2001) to model the relationship between moderators and effect sizes. This macro adjusts the regular weighted least squares multiple regression and delivers correct standard errors and significance testing. The sum of the random effects variance and the estimation variance was calculated as an estimate of the residual variance component. The effect estimates were weighted by the inverse of their residual variance component and used as a dependent measure in the regression. The moderators were integrated into the analysis as predictors.

The individual regression coefficient B for each predictor was used in testing the significance of individual study features. Standard errors were corrected, and confidence intervals were calculated according to Hedges and Olkin (1985).

(1) **Academic performance**

Academic performance overall

Primary school The R^2 coefficient of determination for effect sizes regarding academic performance at primary school was 0.29, indicating that the statistical model accounts for 29% of the variability in the primary school effect sizes of academic performance. For academic performance, effect sizes were higher

- if the intervention was based on social-cognitive theories (B=0.33) rather than on metacognitive theories (reference category). Motivation background led to significantly lower effect sizes (B=−0.38).
- if interventions also included the instruction of metacognitive (B=0.39) and motivational strategies (B=0.36) rather than for interventions that did not (constant).

The results of the regression analysis for primary school concerning the academic performance outcomes are presented in Table 3.

Secondary school The R^2 coefficient of determination for academic performance effect sizes at secondary school was 0.85, indicating that the statistical model accounts for 85% of the variability in the secondary school effect sizes of academic performance. The results of the meta-regression are presented in Table 4. Effect sizes for academic performance overall at secondary school were higher

- if the intervention was based on metacognitive theoretical background (reference category) rather than on social-cognitive (B=−1.41) or motivational theories (B=−0.97).
- if the intervention focused on metacognitive reflection (B=0.82) or motivation strategies (B=0.56) rather than on cognitive strategies (reference category), but higher for interventions promoting cognitive rather than metacognitive strategies (B=−0.64).

Table 3 Stepwise backwards meta-regression analysis for primary school academic performance outcomes (overall)

v=0.15	*B*	SE	−95% CI	+95% CI	*p*
Constant	0.20	0.14	−0.07	0.46	0.15
Motivational theory	−0.38	0.19	−0.74	−0.01	0.04
Social-cognitive theory	0.33	0.13	0.07	0.58	0.0113
Metacognitive strategies	0.39	0.14	0.11	0.67	0.0058
Motivation strategies	0.36	0.13	0.10	0.62	0.0075
Group work	−0.24	0.13	−0.50	0.02	0.0695

v Method of moments random effects variance component

- if group work was used as a teaching method (*B*=0.56).
- if the intervention was conducted by researchers (constant) rather than by regular teachers (*B*=−0.80).
- for interventions conducted in the context of mathematics (reference category) rather than in reading/writing (*B*=−1.00) or others (*B*=−0.92).

Academic performance mathematics

Primary school The R^2 coefficient of determination for effect sizes for mathematics performance at primary school was 0.44, indicating that approximately 44% of the variation in effect sizes for mathematics performance at primary school can be explained by the following moderator variables. Effect sizes for mathematics performance at primary school were higher

- for interventions focusing on cognitive strategy instruction (reference category) rather than on metacognitive reflection (*B*=−1.08).
- for interventions with a large number of sessions (*B*=0.05).

Secondary school The R^2 coefficient of determination for mathematics performance effect sizes at secondary school was 0.94, indicating that 94% of the variability in effect sizes for

Table 4 Stepwise backwards meta-regression analysis for secondary school academic performance outcomes (overall)

v=0.06	*B*	SE	−95% CI	+95% CI	*p*
Constant	1.68	0.31	1.06	2.29	<0.0001
Motivational theory	−0.97	0.36	−1.68	−0.25	0.0078
Social-cognitive theory	−1.41	0.26	−1.93	−0.89	<0.0001
Metacognitive strategies	−0.64	0.19	−1.02	−0.26	0.0010
Motivation strategies	0.56	0.22	0.14	0.99	0.0089
Metacognitive reflection	0.82	0.19	0.46	1.19	<0.0001
Group work	0.56	0.20	0.16	0.96	0.0063
Teacher-directed	−0.80	0.18	−1.16	−0.45	<0.0001
Reading/writing	−1.00	0.32	−1.62	−0.38	0.0017
Rest category	−0.92	0.32	−1.55	−0.29	0.0044

v Method of moments random effects variance component mathematics performance at secondary school may be attributed to the following moderators: Effect sizes representing mathematics performance at secondary school were higher

- if the theoretical background of the intervention focused on motivational (B=0.55) rather than on metacognitive learning theories (reference category). No significant difference was found compared to social-cognitive theories.
- if group work was not used as a teaching method (constant) rather than if it was used (B=−0.65).
- with an increasing number of training sessions (B=0.02).

Academic performance reading/writing

Primary school The R^2 indicated that 19% of the variation of the effect sizes was explained by the model. Effect sizes assessing reading/writing performance at primary school level were higher if the intervention was based on a social-cognitive theoretical background (B= 0.38) rather than on a metacognitive one (reference category).

Secondary school There were not enough effect sizes measuring reading/writing performance at secondary school to conduct meta-analytic regression analyses with this number of predictors.

(2) Strategy use

Primary school The R^2 coefficient of determination for strategy use effect sizes at primary school was 0.33, indicating that the statistical model accounts for 33% of the variability in the primary school effect sizes of strategy use. Table 5 summarizes the results of the meta-regression for strategy use at primary school. Effect sizes for strategy use were higher

- if the intervention was based on a motivational (B=1.12) or on a social-cognitive theoretical background (B=0.68) rather than on a metacognitive one (reference category).
- if the training focused on cognitive (reference category) rather than on motivational strategy instruction (B=−0.45). No difference was found between cognitive and metacognitive strategy instruction.

Table 5 Stepwise backwards meta-regression analysis for primary school strategy use

v=0.12	B	SE	−95% CI	+95% CI	p
Constant	0.56	0.11	0.34	0.77	<0.0001
Motivational theory	1.12	0.27	0.59	1.65	<0.0001
Social-cognitive theory	0.68	0.10	0.48	0.87	<0.0001
Motivation strategies	−0.45	0.13	−0.71	−0.19	0.0008
Metacognitive reflection	0.22	0.11	0.02	0.43	0.0346
Group work	−0.53	0.12	−0.77	−0.29	<0.0001
Teacher-directed	−0.67	0.13	−0.92	−0.42	<0.0001
Reading/writing	−0.34	0.10	−0.52	−0.15	0.0005

v Method of moments random effects variance component

– if the intervention provided metacognitive reflection (B=0.22) rather than focusing on cognitive strategy instruction (reference category).
– if group work was not used as a teaching method (B=−0.53).
– if the training was conducted by researchers (constant) rather than by regular teachers (B=−0.67).
– for interventions conducted in a mathematics context (reference category) rather than in reading/writing (B=−0.34). The analyses did not reveal significant differences between mathematics and the rest category.

Secondary school The R^2 is 0.59, indicating a 59% of variability explanation by the statistical model. Results of this meta-regression are shown in Table 6. The effect sizes measuring strategy use at secondary school were higher

– for interventions based on a metacognitive theoretical background (reference category) rather than on a motivational (B=−1.83) or social-cognitive one (B=−1.67).
– for interventions focusing on motivation strategies (B=0.88) and metacognitive reflection (B=1.45) rather than on cognitive strategy instruction (reference category). No significant differences were found for interventions fostering metacognitive strategy use compared to those emphasizing cognitive strategies.
– if researchers directed the training rather than regular teachers (B=−0.64).
– for interventions conducted in the context of mathematics instruction (reference category) rather than in reading/writing (B=−0.79) or other subjects (B=−0.45).

(3) **Motivational outcomes**

Primary school The R^2 coefficient of determination for motivation effect sizes at primary school was 0.40, indicating that the statistical model accounts for 40% of the variation within the motivation effect sizes at primary school. Table 7 represents an overview of the results of this meta-regression. Effect sizes for motivational outcomes at primary school were higher

– if group work was not used as a method of instruction (B=−0.77).
– if the training was conducted by researchers rather than by regular teachers (B=−0.78).
– if the training consisted of a larger number of sessions (B=0.01).

Table 6 Stepwise backwards meta-regression analysis for secondary school strategy use

v=0.09	B	SE	−95% CI	+95% CI	p
Constant	1.28	0.11	1.06	1.50	<0.0001
Motivational theory	−1.83	0.16	−2.15	−1.51	<0.0001
Social-cognitive theory	−1.67	0.12	−1.91	−1.44	<0.0001
Motivation strategies	0.88	0.10	0.68	1.09	<0.0001
Metacognitive reflection	1.45	0.10	1.26	1.64	<0.0001
Teacher-directed	−0.64	0.09	−0.82	−0.47	<0.0001
Reading/writing	−0.79	0.14	−1.06	−0.52	<0.0001
Other subjects	−0.45	0.10	−0.65	−0.25	<0.0001

v Method of moments random effects variance component

Table 7 Stepwise backwards meta-regression analysis for primary school motivational outcomes

v=0.19	*B*	SE	−95% CI	+95% CI	*p*
Constant	0.122	0.18	0.86	1.58	<0.0001
Cooperative	−0.77	0.20	−1.15	−0.39	0.0001
Teacher-directed	−0.78	0.18	−1.13	−0.43	<0.0001
Number of sessions	0.01	0.01	0.003	0.02	0.0087
Reading/writing	−0.52	0.17	−0.85	−0.20	0.0017
Other subjects	−0.88	0.40	−1.66	−0.09	0.0290

v Method of moments random effects variance component

– for training programmes conducted within mathematics instruction (reference category) rather than in reading/writing (B=−0.52) or other subjects (B=−0.88).

Secondary school For secondary school, effect sizes measuring motivational outcomes could not be analyzed since only one study (Perels et al. 2005) reported results for students' motivation.

Differences between primary and secondary school level

Mean effect sizes at primary versus secondary school In the empty model, the weighted averaged effect sizes did not differ significantly between primary and secondary school when considering the overall measure for all dependent variables or for all academic performance measures together. However, for all more differentiated outcome categories, effect sizes differed significantly between primary and secondary school: Effect sizes for mathematics performance were higher at primary than at secondary school, while for reading/writing performance they were higher at secondary than at primary school. Effect sizes of students' strategy use were slightly higher at secondary school, but motivational outcomes at primary school easily exceeded those measured at secondary school. Yet, this result should be interpreted carefully due to the small number of effect sizes measuring motivation at secondary school level. Mean effect sizes and regression coefficients are presented separately for both school levels in Table 8.

Correlation analyses of predictors

Due to the large number of potential moderators that should be tested within one model, it was not possible to include more detailed sub-categories of the instructed strategies as further moderators in the analyses. Instead, the type of instructed strategy was categorized into three broader instruction categories of cognitive, metacognitive, or motivational strategies. However, more detailed sub-categories were coded from the studies. This information may be particularly interesting since it describes the training contents in more detail. In order not to loose this information, we correlated these sub-categories with the type if theoretical background which was used by the authors of the studies. Significant correlations would provide more information about what the training programmes looked like.

Table 8 Mean effect sizes primary vs. secondary school

	Primary school mean ES (SE)	Secondary school mean ES (SE)	Regression coefficient (p)	Random effects variance component
All dependent variables	0.68 (0.03) n=263	0.71 (0.05) n=94	0.02 (p=0.68)	0.19
Academic performance overall	0.61 (0.05) n=102	0.54 (0.11) n=34	−0.08 (p=0.44)	0.26
Academic performance mathematics[b]	0.96 (0.13) n=25	0.23 (0.08) n=12	−0.70 (p<0.01)	0.17
Academic performance reading/writing[b]	0.44 (0.06) n=55	0.92 (0.20) n=16	0.47 (p<0.01)	0.21
Academic performance other subjects[a]	0.64 (0.09) n=22	0.05 (0.15) n=6	−0.57 (p<0.05)	0.15
Strategy use[a]	0.72 (0.04) n=113	0.88 (0.06)n=54	0.15 (p<0.05)	0.17
Motivation[a]	0.75 (0.09) n=48	0.17 (0.06) n=6 (N=1)	−0.57 (p<0.05)	0.26

[a] Significant differences (on the 5% level) between primary and secondary school mean effect sizes

[b] Significant differences (on the 1% level) between primary and secondary school mean effect sizes

Therefore, correlation analyses were conducted between the predictors' *type of theoretical background* and *type of instructed strategy*. We found significant correlations for training programmes that were based on a metacognitive theoretical background with the instruction of problem solving strategies and with metacognitive reflection. The correlation was negative with motivational strategy instruction. A theoretical focus on motivation correlated significantly with the instruction of cognitive, metacognitive and motivational strategies, but negatively with metacognitive reflection. The analyses revealed negative correlations between a social-cognitive theoretical background and cognitive as well as metacognitive strategy instruction.

For more detailed analyses, each type of theoretical background was correlated with the subcategories of each strategy type (see Table 9). It was not possible to include these subcategories of strategies into the meta-regressions, since the number of predictors would have become too large in relation to the number of effect sizes.

The correlations led to the conclusion that training programmes based on a metacognitive theoretical background focused mainly on problem-solving strategies in combination with metacognitive reflection, but not fundamentally on metacognitive strategy instruction, and even less on motivation strategies. Compared with this, training programmes with a motivational theoretical background emphasized cognitive, metacognitive and motivation strategy instruction by leaving out any metacognitive reflection. No correlational pattern was found for training programmes based on social-cognitive theoretical background.

Discussion

The present meta-analysis investigated 74 studies for the effects of training characteristics at primary and at secondary school level (Table 10).

The results will be discussed against the background of the theories mentioned earlier on the development of metacognition and self-regulated learning between early primary through to secondary school age.

Table 9 Correlations of theoretical background of a study with instruction of subcategories of strategy types

Theoretical background	Metacognitive theoretical background	Social-cognitive theoretical background	Motivational theoretical background
Cognitive strategies			
Elaboration	n.s.	-0.16^{b}	0.39^{b}
Organization	n.s.	-0.18^{b}	0.36^{b}
Problem-solving	0.21^{b}	-0.13^{a}	n.s.
Metacognitive reflection			
Reasoning	0.34^{b}	-0.25^{b}	n.s.
Knowledge about strategies	0.19^{b}	n.s.	n.s.
Benefit of strategy use	0.23^{b}	n.s.	n.s.
Metacognitive strategies			
Planning	-0.15^{b}	n.s.	0.31^{b}
Monitoring	n.s.	n.s.	0.19^{b}
Evaluation	n.s.	n.s.	0.20^{b}
Motivation strategies			
Resource management	-0.11^{a}	0.13^{a}	n.s.
Causal attribution	-0.14^{b}	n.s.	0.32^{b}
Action control	-0.39^{b}	n.s.	0.49^{b}
Feedback	n.s.	0.13^{a}	-0.13^{a}

[a] Significant correlation on the 5%-level

[b] Significant correlation on the 1%-level

n.s=not significant

Table 10 Summary of main effects

	Primary school	Secondary school
Highest effect size in…	Motivational aspects maths performance	Strategy use reading/writing performance
Direction of the training	Effect sizes are higher when the training is conducted by researchers instead of regular teachers	
School subject domain	Interventions attain higher effect sizes when conducted in the scope of mathematics than in reading/writing or other subjects	
Theoretical background of the training program	Effect sizes are higher if the intervention is based on social-cognitive learning theories	Effect sizes are higher if the intervention is based on metacognitive learning theories
Group work	Negative impact on effect sizes	Positive impact on effect sizes
Type of strategy	For maths performance, cognitive strategy instruction leads to higher effect sizes than metacognitive reflection, but for strategy use it is the opposite	Instruction of motivational strategies as well as metacognitive reflection is superior to interventions that mainly focus on cognitive strategies
Duration of the training program	Effect sizes increased with the number of training sessions	

Drawing inferences from the results

With regard to students' academic performance:

(1) For primary school level, training programmes that were developed based on social-cognitive theories on self-regulated learning reached higher effects than those based on theories emphasizing motivational aspects or metacognition. For secondary school level, programmes based on metacognitive theories had the highest effects. As the literature review on the development of metacognition revealed, metacognitive strategy use arises during the elementary school years, but the development continues during the secondary school grades (e.g., Alexander et al. 1995; Paris and Winograd 1999; Schneider and Sodian 1997; Veenman et al. 2004), and even remains incomplete over the life-span (Kuhn 1999). According to Paris and Newman (1990), children entering primary school rarely reflect and control their learning compared to children entering secondary school. As secondary school students already dispose of metacognitive knowledge and strategies, training that emphasize these metacognitive aspects can be functional, while younger students, who do not yet dispose of a strategy repertoire, might still need more support, so that training based on motivational theories is more effective.

(2) At primary school level, effect sizes were higher if metacognitive strategies were trained, while at secondary school level, effect sizes were higher for training programmes including metacognitive reflection. This is the same for both, students' academic performance, as well as their use of strategies. According to Alexander et al. (1998), children's strategic behaviour changes as they become more experienced and competent in a subject by being more effective, flexible and sophisticated. Young children, whose metacognitive and metastrategic knowledge is still developing (Kuhn 1999), might therefore benefit more from pure instruction of metacognitive strategies in order to broaden their strategy repertoire, while older students benefit more from elaborating the application of strategies that they might already possess in order to reach a level of more sophisticated strategy use (see Schneider and Sodian 1997). This result also supports developmental theories of self-regulated learning which postulate that learners have to pass through different levels of self-regulation until they achieve a level of self-regulating their learning in an adaptive way and in changing conditions (Zimmerman 2002). Following Zimmerman's model of the development of self-regulated learning (2002), learners start with learning by modelling and imitating, so that they are still dependent on external feedback. Only on the higher developmental levels can the learner control and regulate their own learning process independently of others. In these stages, metacognitive reflection about when and how to use which strategy can take place in an independent way, while students still need more support at the earlier levels (Zimmerman 2002).

(3) Effect sizes measuring students' maths performance were higher for primary school students, while effect sizes that measured reading/writing performance turned out to be higher at secondary school level. The fact that the effect sizes for maths performance of primary school studies even exceeded those of secondary school studies reinforces the finding that students can benefit from strategy training already at primary school level (Dignath et al. 2008; Hattie et al. 1996). With regard to the higher effect sizes in reading/writing at secondary school, research on the development of metacognition has revealed that especially in the context of reading and writing, inexperienced students have problems with using metacognitive

strategies, as they do not have enough cognitive capacities left for using strategies in addition to the demanding task of reading or writing (Alexander et al. 1998). Older students, who have automated the process of reading and writing, still have free capacity for metacognitive processes, and can therefore benefit more from strategy training in this context. Furthermore, this result is concordant with findings of the review of Alexander et al. (1995) on metacognitive development studies: While students already acquire maths strategies during the early primary school years, they only start applying text comprehension strategies in the higher grades.

Only little empirical research has examined the impact of contextual differences in achievement beliefs between classes of different academic disciplines (Wolters and Pintrich 1998). Wigfield (1994) reports a negative development of students' achievement beliefs as they get older, which is more pronounced in the area of mathematics than in other areas. In addition, students value mathematics more highly in elementary school than in high school, while the older students value language arts more (Wigfield 1994). As expectancies are strongly related to performance (Pintrich and De Groot 1990; Wigfield 1994), students' lower efficacy beliefs might lead to a lower efficacy of the intervention programme in the respective subject, while those subjects, in which students have higher achievement beliefs, might work better for the training programmes.

(4) Interventions are more effective the longer they are, for both school levels. This result is in line with former research on the development of metacognition and self-regulation, emphasizing the importance of developmental aspects of strategy use: As students gain experience in strategy use, their strategic behaviour shifts in both, a quantitative and a qualitative way: Students' strategy use becomes more automated and sophisticated with time. Moreover, children often do not generalize the use of strategies to new contexts (Alexander et al. 1998). Providing students with opportunities to practice strategy use will foster the transfer of metastrategic knowledge to real learning contexts. Consequently, the development of strategic behaviour is not only related with age, but also develops with experience (Alexander et al. 1998). Following a large amount of research on strategy interventions, learners need time to adopt strategies into their learning behaviour. Interventions should therefore last for a longer time period to allow for intensive acquisition and practice of self-regulated learning strategies (see e.g., Pressley et al. 2006; Veenman et al. 2006).

With regard to students' strategy use:

(1) The finding that effect sizes of students' strategy use were higher at secondary school is in line with former research, having shown already that older students learn in a more strategic way (Paris and Newman 1990; Zimmerman 1990). This might be due to the fact that secondary school students already dispose of a complex strategy repertoire, resulting from their experience with strategic situations, while primary school students might not yet possess automized backup strategies (Alexander et al. 1995).

(2) Primary school students achieved higher effects regarding motivational outcomes than secondary school students. This result is concordant with earlier findings, demonstrating that young children are already motivated to learn when they arrive at school—however, this motivation declines during schooling (e.g. Helmke 1993; Krapp 1998; Spinath and Spinath 2005). In general, students' achievement beliefs become more negative with increasing age, especially during early adolescence (Wigfield 1994).

Yet, the result for motivational outcomes is only based on one single study conducted at secondary school that reported motivational outcomes (Perels et al. 2005) and should therefore not be generalized.

(3) With regard to students' strategy use, the effect sizes at primary school level were higher when interventions were developed against the background of theories that emphasized motivational aspects of self-regulated learning. According to Dweck and Elliot (1983), young children attribute success and failure more often to their effort, while children above the age of 12 relate it more often to fixed ability. Motivational strategies or motivation of strategy use might therefore be more accessible to younger children.

(4) At secondary school level, effect sizes were highest for training programmes that were developed based on metacognitive theories. In order to see what distinguishes the interventions from one another when based on the various theoretical backgrounds, it seems interesting to look in more detail at the training contents of the programmes that were based on the different theoretical research traditions: As the correlations between the *type of theoretical background* and the *type of instructed strategy* showed, it is not possible to conclude that training programmes based on metacognitive theory would focus more on metacognitive strategies, while those based on motivation theories would emphasize mainly motivation strategies. Rather, the correlation analyses revealed that for all three types of theoretical orientations, the instruction of metacognitive strategies seems to be relatively equal. Training programmes with a social-cognitive background basically focused on any strategy instruction, combined with feedback and resource management strategies. This focus on strategies combined with strategy-related feedback seems to be easiest to learn and most efficient for younger students (e.g., Schunk 1994, 1996, 1997) as is noticeable in the effect sizes measuring academic performance. In contrast, training programmes with a theoretical focus on metacognition included many different types of higher-order thinking strategies, namely problem-solving strategies, and metacognitive reflection. These training programmes, which focus on combining metacognitive strategies with complex cognitive strategies and metacognitive reflection, revealed the highest effect sizes at secondary school level; thus they might be very efficient, but may be too difficult for younger students (see Zimmerman 1990). The programmes with a motivational theoretical background integrated many different types of strategies (cognitive and metacognitive strategies, and some types of motivational strategies). However, they left out the most effective characteristics from both school levels: These interventions did not provide feedback, which is helpful for younger students (Schunk 1997), and they did not foster metacognitive reflection (e.g., Schraw 1998; Butler 2002), which improves programmes for older students.

(5) For both school levels, effect sizes were higher when metacognitive reflection was included in the training. Instructing metacognitive strategies—like planning, monitoring, and evaluating one's learning process—does not improve learning outcomes, strategy use, or motivation per se. There are some supplementary components that seem to make the promotion of self-regulated learning effective: Students need feedback about their strategy use (Zimmerman 2002), and they need knowledge about strategies and about the benefit of using them (Schraw 1998).

(6) Moreover, for both school types training programmes reached higher effects when the training was conducted in the scope of maths rather than reading or writing. As mentioned above, processes of reading and writing are so demanding to inexperienced students, that the additional cognitive capacity, which would be required for strategy use, is too limited (Alexander et al. 1998).

Moreover, Wolters and Pintrich (1998) reported that students tend to view mathematics as more important, useful, and interesting than language arts or social studies, which could be an explanation for students' potentially higher commitment in mathematics than in reading and writing. Thus, Wolters and Pintrich (1998) did not find a greater use of strategies in mathematics than in other subjects. Although there might be variation between subject areas, the relations between motivation and cognition seems to be stable across the different subjects (Wolters and Pintrich 1998).

(7) Furthermore, for both school types, effect sizes were higher if the training was provided by researchers rather than by regular class teachers. This is an alarming result as it is an essential long-term goal of educational research to be able to implement relevant research results into school practice (De Corte 2000). According to Waeytens et al. (2002), teachers lack knowledge about the concept of self-regulated learning. Observation studies also showed that they spend only little of their instruction time on strategy teaching (Hamman et al. 2000). Therefore, when implementing an intervention to promote self-regulated learning by the regular teachers, extensive teacher training would be necessary. Yet, following Kline et al. (1992), teachers lack an overall instructional plan, the required preparation time for strategy instruction, support with implementing strategy instruction, as well as the necessary skills that teachers and managers need for effective implementation of those strategies. In addition, whether teachers even realize changes in their instruction is dependent on their prior beliefs and value orientations. Therefore, providing them with information is not sufficient, but should be completed by transforming the information into tools usable for teachers and by involving the teachers in the research project (De Corte 2000). Thus, the low effect of interventions conducted by teachers might be a consequence of inadequate or insufficient teacher training. The effects of teacher training on the teachers themselves should also be investigated when implementing a training programme directed by teachers. More information on teacher training of the studies under investigation would have been necessary in order to get a detailed picture on the difficulties of implementing the training contents in the classroom. When developing a training programme, it should be clear that teachers are the most important contact person for the students, who stay close to them for a long time period and could therefore help students to automate strategy use in the long run. Furthermore, teachers can function as facilitators of students' accumulating knowledge and skills necessary to self-regulate their learning.

(8) Finally, at primary school, interventions attained higher effect sizes on strategy use if they did not include group work as a teaching method. Meanwhile, there is some research showing the positive impact of cooperative learning on students' performance, strategy use, and motivation (e.g., Guthrie et al. 1998; Slavin 1996)—at elementary as well as at secondary school level (Slavin 1989). Even very young students were found to benefit from collaborative learning settings (e.g. Whitebread 2007). In the studies included in this meta-analysis we only found 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 in the classroom. We also did not find any information about the experiences of students with cooperative learning, and whether they received any instruction about cooperative learning. As it is obvious that the positive effects of cooperative learning 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. Older students have a higher probability of already knowing about cooperative working, since children develop cooperation skills during middle childhood (Cooper et al. 1982). The impact of this prior knowledge on cooperative learning at various ages has not been studied (Slavin 1987). As strategy development is more likely to result from cooperative learning when the collaborators are already well informed and skilled (Alexander et al. 1998), a detailed instruction of cooperative skills might be necessary. However, this does not always take place: Veenman et al. (2000) observed that teachers devoted only little time to the instruction of cooperative skills, and the implementation of cooperative learning did not meet the characteristics recommended in the literature about effective cooperative learning (Veenman et al. 2000). Thus, further research should focus more on the implementation of training, including skills of working cooperatively in the classroom, especially when assigning more learning responsibility to the students. This goes hand in hand with further research on professional development to provide teachers with the instructional competencies needed to support cooperative learning in the classroom (Slavin 1996; Veenman et al. 2000).

Limitations of the findings

Before coming to the conclusions, which can be drawn from this meta-analysis, it is necessary to consider its limitations:

Firstly, during the literature search, studies can be selected in a biased way, e.g. by only including published studies, as we did in this review. Following Glass (1976), published studies are more likely to report significant results, which can lead to a publication bias. Effect sizes might therefore be lower on average if considering non-significant results which are usually not published. However, mean effect sizes ranged between 0.60 and 0.90, which is very high for interventions in educational settings: Following a meta-synthesis conducted by Sipe and Curlette (1997) on 103 meta-analyses that investigated the effects of educational intervention, published from 1984 through to 1993, an unweighted average effect size of 0.38 was suggested as a benchmark of effectiveness. Even if effect sizes were lower by incorporating unpublished studies, the training effects would still be substantial.

A second critical point to mention is that in meta-analysis studies of differing quality are often taken into account together, giving equal weights to studies of high and low quality. It was not possible to weight studies in relation to their reliability, since not all studies reported a comparable reliability indicator; and weighting of only parts of the studies seems to be problematic (Cooper and Hedges 1994). However, we took the sample size into account by weighting the studies with the inverse of the variance, allowing a higher impact on larger samples which are assumed to more closely approximate the actual effects (Hedges and Olkin 1985).

Thirdly, generalization is limited in relation to the type of intervention, as we did not include computerized intervention in the analysis. However, this kind of training takes place more and more often (Boekaerts and Corno 2005). Nevertheless, we decided not to include these interventions in the analysis in order to avoid comparing “apples with oranges” (Hedges and Olkin 1985): Computerized interventions in school settings differ in many aspects from the interventions included here, making analyses more complex. Due to the large number of predictors included in the analyses and the limited number of effect sizes, it was not possible to realise more complex models in this study.

Implications

It can be concluded from the results that self-regulated learning can be promoted in an effective way—at primary as well as at secondary school level. For future interventions at primary school level, students' need for encouragement and motivational support should be taken into account, while at secondary school level, interventions should build on the strategic repertoire that students have already acquired by then. For both school levels, long-term interventions should provide enough opportunities to practice and automate strategy use in order to facilitate transfer to other learning situations. In addition, the impact of metacognitive reflection should be acknowledged.

Yet, thorough research is needed to improve teacher training and the implementation of these interventions in the classroom, combined with a close collaboration between researchers and practitioners. Moreover, further research should meet the challenge of working on self-regulation programmes in the reading/writing context to achieve effects as high as in the field of mathematics. Furthermore, the negative impact of group work on primary school students' strategy use and motivation leads to the conclusion again that more research is needed in the field of how to implement research into real classroom settings by integrating the teachers as important collaborators.

The evidence presented in this review shows that there is already a large variety of high-quality research about how to promote self-regulated learning amongst students. This should encourage researchers and teachers to collaborate by taking the next step of investigating how these programmes can be implemented successfully in the classroom.

Acknowledgements We are grateful to the editor, as well as to the anonymous reviewers for their useful comments. Moreover, we thank Hans-Peter Langfeldt for his helpful remarks on an earlier draft of this article. Furthermore, we appreciated the competent statistical advice of Reyn van Ewijk very much. Finally, we thank the student assistants Adriana Oppitz, Valentina Tesky and Sarah Müller for their support with coding the studies together with the first author.

Appendix

Computation of Effect Sizes When analyzing the size of interaction effects in intervention studies with a nonrandomized control-group design, as it is common for research in educational settings, potential group differences before the start of the intervention have to be taken into account. Thus, the effect gain (Rustenbach 2003) was computed by first estimating the pre-standardized mean differences and the post-standardized mean difference separately (Hedges and Olkin 1985), and then subtracting the pre-effect size from the post-effect size. The variance for this effect gain is substantially overestimated, which leads to more conservative testing (Rustenbach 2003). For studies, which only reported that pretest differences were not significant, without providing this pretest data, the post-standardized mean differences between treatment and control group were computed (Hedges and Olkin 1985). In the case that mean and standard deviation were not reported, the effect gain was estimated by taking the square root of the F-value and multiplying it with the squared sum of twice the sample size of the treatment and twice the sample size of the control group

(Viechtbauer 2006): $\sqrt{F} \times (2 \times n_{EG} + 2 \times n_{CG})^2$. The variance of the effect gain was calculated by taking twice the sum of the inverse of the treatment and control group (Viechtbauer 2006). All effect sizes were therefore scaled in the same metric, resulting in the standardized mean differences, which were adjusted to pretest differences. This equivalence is important when combining effect sizes estimated in different ways. Effect sizes were computed in such a way that a positive effect size indicates a favourable outcome for the treatment group.

References

Alexander, P. A., Carr, M., & Schwanenflugel, P. J. (1995). Development of metacognition in gifted children: Directions for future research. *Developmental Review*, *15*, 1–37.

Alexander, P. A., Graham, S., & Harris, K. R. (1998). A perspective on strategy research: Progress and prospects. *Educational Psychology Review*, *10*(2), 129–154.

Bandura, A. (1989). Social cognitive theory. In R. Vasta (Ed.), *Annals of child development* (Vol.6. Six theories of child development (pp. 1–60). Greenwich, CT: JAI.

Becker, B. J. (1988). Synthesizing standardized mean-change measures. *British Journal of Mathematical and Statistical Psychology*, *41*, 257–278.

Becker, J. T. (2005). *Policy on meta-analysis.* Retrieved July 24, 2006, from http://www.apa.org/journals/neu/meta-analysis_policy.pdf.

Berkey, C. S., Hoaglin, D. C., Antczak-Bouckoms, A., Mosteller, F., & Colditz, G. A. (1998). Meta-analysis of multiple outcomes by regression with random effects. *Statistics in Medicine*, *17*, 2537–2550.

Biemiller, A., Shany, M., Inglis, A., & Meichenbaum, D. (1998). Factors influencing children's acquisition and demonstration of self-regulation on academic tasks. In D. H. Schunk, & B. J. Zimmerman (Eds.), *Self-regulated learning. From teaching to self-reflective practice* (pp. 203–224). New York: Guilford.

Boekaerts, M. (1999). Self-regulated learning: Where we are today. *International Journal of Educational Research*, *31*, 445–457.

Boekaerts, M., & Corno, L. (2005). Self-regulation in the classroom: A perspective on assessment and intervention. *Applied Psychology: An International Review*, *54*(2), 199–231.

Boekaerts, M., Pintrich, P. R., & Zeidner, M. (2000). *Handbook of self-regulated learning*. San Diego: Academic.

Brockwell, S. E., & Gordon, I. R. (2001). A comparison of statistical methods for meta-analysis. *Statistics in Medicine*, *20*, 825–840.

Bronson, M. B. (2000). Supporting self-regulation in primary school children. In M. B. Bronson (Ed.), *Self-regulation in early childhood* (pp. 221–242). New York: Guilford.

Brown, R., Pressley, M., Van Meter, P., & Schuder, T. (1996). A quasi-experimental validation of transactional strategies instruction with low-achieving second-grade readers. *Journal of Educational Psychology*, *88*(1), 18–37.

Butler, D. L. (2002). Individualizing instruction in self-regulated learning. *Theory and Practice*, *41*(2), 81–92.

Cohn, L. D., & Becker, B. J. (2003). How meta-analysis increases statistical power. *Psychological Methods*, *8*(3), 243–253.

Cooper, H., & Hedges, L. (1994). *The handbook of research synthesis*. New York: Russel Sage Foundation.

Cooper, C. R., Marquis, A., King, J., & Moore, M. S. (1982). *Emerging developmental issues in the structure and process of peer learning in classrooms*. Paper presented at the annual convention of the American Educational Research Association, New York, March. [cited following Slavin, R.E. (1987). Developmental and motivational perspectives on cooperative learning: a reconciliation. *Child Development*, *58*, 1161–1167.]

Cultice, J. C., Somerville, S. C., & Wellman, H. M. (1983). Preschoolers' memory monitoring: Feeling-of-knowing judgements. *Child Development*, *54*, 1480–1486.

De Corte, E. (2000). Marrying theory building and the improvement of school practice: A permanent challenge for instructional psychology. *Learning and Instruction*, *10*, 249–266.

De Corte, E., Verschaffel, L., & Masui, C. (2004). The CLIA-model: A framework for designing powerful learning environments for thinking and problem solving. *European Journal of Psychology of Education*, *19*(4), 365–384.

Dickersin, K. (1994). Research registers. In H. Cooper, & L. Hedges (Eds.), *The handbook of research synthesis* (pp. 71–84). New York: Russel Sage Foundation.

Dignath, C., Büttner, G., & Langfeldt, H. P. (2008). How can primary school students learn self-regulated learning strategies most effectively? A meta-analysis on self-regulation training programmes. *Educational Research Review*, *3*, 101–129.

Dweck, C. S., & Elliot, E. S. (1983). Achievement motivation. In P. Mussen (Ed.), *Carmichael's manual of child psychology* (pp. 643–691). New York: Wiley.

EU Council. (2002). *Council Resolution of 27 June 2002 on Lifelong Learning*. Official Journal of the European Communities, July 9, 2002.

Flavell, J. H., Miller, P. H., & Miller, S. A. (1993). *Cognitive development*. Englewood Cliffs, NJ: Prentice Hall.

Glass, G. V. (1976). Primary, secondary, and meta-analysis. *Educational Researcher*, *5*, 3–8.

Gleser, L. J., & Olkin, I. (1994). Stochastically dependent effect sizes. In H. Cooper, & L. V. Hedges (Eds.), *The handbook of research synthesis* (pp. 339–356). New York: Russell Sage Foundation.

Guthrie, J. T., Cox, K. E., Anderson, E., Harris, K., Mazzoni, S., & Rach, L. (1998). Principles of integrated instruction for engagement in reading. *Educational Psychology Review*, *10*(2), 177–199.

Hamman, D., Berthelot, J., Saia, J., & Crowley, E. (2000). Teachers' coaching of learning and its relation to students' strategic learning. *Journal of Educational Psychology*, *92*(2), 342–348.

Hattie, J. A., Biggs, J., & Purdie, N. (1996). Effects of learning skills interventions on student learning: A meta-analysis. *Review of Educational Research*, *66*(2), 99–136.

Hedges, L. V., & Olkin, I. (1985). *Statistical methods for meta-analysis*. San Diego, CA: Academic.

Hedges, L. V., & Pigott, T. D. (2004). The power of statistical tests for moderators in meta-analysis. *Psychological Methods*, *9*(4), 426–445.

Heij, C., De Boer, P., Franses, , Kloek, T., & Van Dijk, H. K. (2004). *Econometric methods with applications in business and economics*. Oxford: Oxford University Press.

Helmke, A. (1993). Die Entwicklung der Lernfreude vom Kindergarten bis zur 5. Klassenstufe. [Development of affective attitudes towards learning from kindergarten to grade five]. *Zeitschrift fuer Paedagogische Psychologie*, *7*(2/3), 77–86).

Higgins, J. P. T., & Thompson, S. G. (2004). Controlling the risk of spurious findings from meta-regression. *Statistics in Medicine*, *23*, 1663–1682.

Klieme, E., Artelt, C., & Stanat, P. (2001). Fächerübergreifende Kompetenzen: Konzepte und Indikatoren. In F. E. Weinert (Ed.), *Leistungsmessung in Schulen* (pp. 203–219). Weinheim: Beltz.

Kline, F. M., Deshler, D. D., & Schumaker, J. B. (1992). Implementing learning strategy instruction in class settings: A research perspective. In M. Pressley, K. R. Harris, & J. T. Guthrie (Eds.), *Promoting academic competence and literacy in school* (pp. 361–406). New York: Academic.

Kramarski, B., & Mevarech, Z. R. (2003). Enhancing mathematical reasoning in classroom: The effects of cooperative learning and the metacognitive training. *American Educational Research Journal*, *40*(1), 281–310.

Krapp, A. (1998). Entwicklung und Foerderung von Interessen im Unterricht [Development and promotion of interest in instruction]. *Psychologie in Erziehung und Unterricht*, *44*, 185–201.

Kuhn, D. (1999). A developmental model of critical thinking. *Educational Researcher*, *28*(2), 16–26.

Lipsey, M. W., & Wilson, D. B. (1993). The efficacy of psychological, educational, and behavioral treatment: Confirmation from meta-analysis. *American Psychologist*, *48*, 1181–1209.

Lipsey, M. W., & Wilson, D. B. (2001). *Practical meta-analysis*. Thousand Oaks, California: Sage.

Mayer, R. E., & Wittrock, M. C. (1996). Problem-solving transfer. In D. C. Berliner, & R. C. Calfee (Eds.), *Handbook of educational psychology*. New York: Macmillan.

McCombs, B. L., & Marzano, R. J. (1990). Putting the self in self-regulated learning: The self as agent in integrating will and skill. *Educational Psychologist*, *25*(1), 51–69.

Morris, S. B., & DeShon, R. P. (2002). Combining effect size estimates in meta-analysis with repeated measures and independent-groups designs. *Psychological Methods*, *7*(1), 105–125.

Overton, R. C. (1998). A comparison of fixed-effects and mixed (random-effects) models for meta-analysis tests of moderator variable effects. *Psychological Methods*, *3*(3), 354–379.

Paris, S. G., & Newman, R. S. (1990). Developmental aspects of self-regulated learning. *Educational Psychologist*, *25*(1), 87–102.

Paris, S. G., & Paris, A. H. (2001). Classroom applications of research on self-regulated learning. *Educational Psychologist*, *36*(2), 89–101.

Paris, S. G., & Winograd, P. (1999). The role of self-regulated learning in contextual teaching: principles and practices for teacher preparation. Contextual teaching and learning: Preparing teachers to enhance student success in and beyond school (pp. 219-252). ERIC Clearinghouse on Teaching and Teacher Education, AACTE.

Perels, F., Gürtler, T., & Schmitz, B. (2005). Training of self-regulatory and problem-solving competence. *Learning and Instruction*, *15*, 123–139.

Perry, N. E., Phillips, L., & Dowler, J. (2004). Examing features of tasks and their potential to promote self-regulated learning. *Teachers College Record*, *106*(9), 1854–1878.
Perry, N. E., VandeKamp, K. O., Mercer, L. K., & Nordby, C. J. (2002). Investigating teacher–student interactions that foster self-regulated learning. *Educational Psychologist*, *37*(1), 5–15.
Piaget, J. (1954). *The construction of reality in the child*. New York: Basic Books.
Pintrich, P. R. (1999). The role of motivation in promoting and sustaining self-regulated learning. *International Journal of Educational Research*, *31*, 459–470.
Pintrich, P. R., & De Groot, E. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology*, *82*, 33–40.
Pressley, M., Graham, S., & Harris, K. (2006). The state of educational intervention research as viewed through the lens of literacy intervention. *British Journal of Eductional Psychology*, *76*, 1–19.
Robinson, J. A., & Kingsley, M. E. (1977). Memory and intelligence: Age and ability differences in strategies and organization of recall. *Intelligence*, *1*(3), 318–330.
Rojas-Drummond, S., Hernández, G., Velez, M., & Villagrán, G. (1998). Cooperative learning and the appropriation of procedural knowledge by primary school children. *Learning and Instruction*, *8*, 37–62.
Rustenbach, S. J. (2003). *Metaanalyse. Eine anwendungsorientierte Einführung* [Meta-analysis: An application-oriented introduction]. Göttingen: Huber.
Schneider, W., & Sodian, B. (1997). Memory strategy development: Lessons from longitudinal research. *Developmental Review*, *17*, 442–461.
Schraw, G. (1998). Promoting general metacognitive awareness. *Instructional Science*, *26*, 113–125.
Schunk, D. H. (1994). *Goal and self-evaluative influences during children's mathematical skill acquisition*. Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, USA, April.
Schunk, D. H. (1996). *Self-evaluation and self-regulated learning.* Paper presented at the Graduate School and University Center, City University of New York, New York. (ERIC Document Reproduction Service No. ED 403 233), October.
Schunk, D. H. (1997). *Self-Monitoring as a motivator during instruction with elementary school students*. Paper presented at the Annual Meeting of the American Educational Research Association, Chicago. (ERIC Document Reproduction Service No. ED 404 035), March.
Schunk, D. H., & Zimmerman, B. J. (1998). *Self-Regulated Learning. From Teaching to Self-Reflective Practice*. New York: Guilford.
Seidel, T., & Shavelson, R. J. (2007). Teaching effectiveness research in the past decade: The role of theory and research design in disentangling meta-analysis results. *Review of Educational Research*, *77*(4), 454–499.
Shadish, W. R., & Haddock, C. K. (1994). Combining estimates of effect size. In H. Cooper, & L. V. Hedges (Eds.), *The handbook of research synthesis* (pp. 261–281). New York: Russell Sage Foundation.
Sipe, T. A., & Curlette, W. L. (1997). A meta-synthesis of factors related to educational achievement: A methodological approach to summarizing and synthesizing meta-analyses. *International Journal of Educational Research*, *25*(7), 583–698.
Slavin, R. E. (1987). Developmental and motivational perspectives on cooperative learning: A reconciliation. *Child Development*, *58*, 1161–1167.
Slavin, R. E. (1989). Research on cooperative learning: Consensus and controversy. *Educational Leadership*, *47*(4), 52–55.
Slavin, R. E. (1996). Research for the future. Research on cooperative learning and achievement: What we know, what we need to know. *Contemporary Educational Psychology*, *21*, 43–69.
Spinath, B., & Spinath, F. (2005). Longitudinal analysis of the link between learning motivation and competence beliefs among elementary school children. *Learning and Instruction*, *15*, 87–102.
Stevens, R. J., & Slavin, R. E. (1992). The cooperative elementary school: Effects on students' achievement, attitudes and social relations. Baltimore, ND: Center for Research on Effective Schooling for Disadvantaged Students (ERIC Document Reproduction Service No. ED 340 098).
Veenman, S., Kenter, B., & Post, K. (2000). Cooperative learning in Dutch primary classrooms. *Educational Studies*, *26*(3), 281–302.
Veenman, M. V. J., & Spaans, M. A. (2005). Relation between intellectual and metacognitive skills: Age and task differences. *Learning and Individual Differences*, *15*, 159–176.
Veenman, M. V. J., Van Hout-Wolters, B. H. A. M., & Afflerbach, P. (2006). Metacognition and learning: conceptual and methodological considerations. *Metacognition and Learning*, *1*, 3–14.
Veenman, M. V. J., Wilhelm, P., & Beishuizen, J. J. (2004). The relation between intellectual and metacognitive skills from a developmental perspective. *Learning & Instruction*, *14*, 89–109.
Viechtbauer, W. (2006). *MiMa: An S-Plus/R function to fit meta-analytic mixed-, random- and fixed effects models [Computer software and manual]*. Retrieved November 21, 2006 from http://www.wvbauer.com/.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Waeytens, K., Lens, W., & Vandenberghe, R. (2002). 'Learning to learn': Teachers' conceptions of their supporting role. *Learning and Instruction*, *12*, 305–322.

Waters, H. S., & Andreassen, C. (1983). Children's use of memory strategies under instruction. In M. Pressley, & J. R. Levin (Eds.), *Cognitive strategy research: Psychological foundations* (pp. 3–24). New York: Springer.

Weinstein, C. E., Husman, J., & Dierking, D. R. (2000). Self-Regulation Interventions with a Focus on Learning Strategies. In M. Boekaerts, P.R. Pintrich & Zeidner (Eds.), *Handbook of self-regulated learning* (pp.728-749). San Diego: Academic.

Weinstein, C. E., & Mayer, R. E. (1986). The teaching of learning strategies. In M. Wittrock (Ed.), *The handbook of research on teaching* (pp. 315–327). New York: Macmillan.

Whitebread, D. (1999). Interactions between children's metacognitive abilities, working memory capacity, strategies and performance during problem-solving. *European Journal of Psychology of Education*, *14* (4), 489–507.

Whitebread, D. (2007). *Towards a pedagogy for teaching thinking and developing metacognitive abilities in young children*. Paper presented at the 12th Biennial Conference for Research on Learning and Instruction. Budapest, Hungary, August.

Wigfield, A. (1994). Expectancy-value theory of achievement motivation: A developmental perspective. *Educational Psychology Review*, *6*, 49–77.

Winne, P. H. (2005). A perspective on state-of-the-art research on self-regulated learning. *Instructional Science*, *33*, 559–565.

Wolters, C. A., & Pintrich, P. R. (1998). Contextual differences in student motivation and self-regulated learning in mathematics, English, and social studies classrooms. *Instructional Science*, *26*, 27–47.

Zeidner, M., Boekaerts, M., & Pintrich, P. (2000). Self-regulation: Directions and challenges for future research. In M. Boekaerts, P. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 750–768). San Diego, CA: Academic.

Zimmerman, B. J. (1986). Becoming a self-regulated learner; which are the key subprocesses? *Contemporary Educational Psychology*, *11*, 307–313.

Zimmerman, B. J. (1990). Self-regulated learning and academic achievement: An overview. *Educational Psychologist*, *25*(1), 3–17.

Zimmerman, B. J. (2001). Theories of self-regulated learning and academic achievement: An overview and analysis. In B. J. Zimmerman, & D. H. Schunk (Eds.), *Self-regulated learning and academic achievement: Theoretical perspectives* (pp. 1–37). Mahwah, NJ: Erlbaum.

Zimmerman, B. J. (2002). Achieving academic excellence: A self-regulatory perspective. In M. Ferrari (Ed.), *The pursuit of excellence through education* (pp. 85–110). Mahwah, NJ: Lawrence Erlbaum.

Zimmerman, B. J., & Bandura, A. (1994). Impact of self-regulatory influences on writing course attainment. *American Educational Research Journal*, *31*(4), 845–862.

Studies Included in the Meta-Analysis

Adey, P., & Shayer, M. (1993). An exploration of long-term far-transfer effects following an extended intervention program in the high school science curriculum. *Cognition and Instruction*, *11*(1), 1–29.

Allsopp, D. H. (1997). Using classwide peer tutoring to teach beginning algebra problem-solving skills in heterogeneous classrooms. *Remedial and Special Education*, *18*(6), 367–379.

Ashman, A. F., & Conway, R. N. (1993). Teaching students to use process-based learning strategies and problem solving strategies in mainstream classes. *Learning and Instruction*, *3*(2), 73–92.

Benito, Y. M., Foley, C. L., Lewis, C. D., & Prescott, P. (1993). The effect of instruction in question/answer relationships and metacognition on social studies comprehension. *Journal of Research in Reading*, *16* (1), 20–29.

Bimmel, P. E., van den Bergh, H., & Oostdam, R. J. (2001). Effects of strategy training on reading comprehension in first and foreign language. *European Journal of Psychology of Education*, *16*(4), 509–529.

Blank, L. M. (2000). A metacognitive learning cycle: A better warranty for student understanding? *Science Education*, *84*(4), 486–506.

Bornas, X., & Servera, M. (1992). Cognitive training programs to reduce impulsivity-related achievement problems: The need of in-classroom interventions. *Learning and Instruction*, *2*(2), 89–100.

Cardelle Elawar, M. (1992). Effects of teaching metacognitive skills to students with low mathematics ability. *Teaching and Teacher Education*, *8*(2), 109–121.

Cardelle Elawar, M. (1995). Effects of metacognitive instruction on low achievers in mathematics problems. *Teaching and Teacher Education*, *11*(1), 81–95.

Carriedo, N., & Alonso-Tapia, J. (1996). Main idea comprehension: Training teachers and effects on students. *Journal of Research in Reading*, *19*(2), 128–153.

Chan, L. K. S. (1996). Combined strategy and attributional training for seventh grade average and poor readers. *Journal of Research in Reading*, *19*(2), 111–127.

De Jager, B., Jansen, M., & Reezigt, G. (2005). The development of metacognition in primary school learning environments. *School Effectiveness and School Improvement*, *16*(2), 179–196.

Desoete, A., Roeyers, H., & De Clercq, A. (2003). Can offline metacognition enhance mathematical problem solving? *Journal of Educational Psychology*, *95*(1), 188–200.

Fuchs, L. S., Fuchs, D., Prentice, K., Burch, M., Hamlett, C. L., Owen, R., et al. (2003). Enhancing third-grade students' mathematical problem solving with self-regulated learning strategies. *Journal of Educational Psychology*, *95*(2), 306–315.

Gallini, J. K., Spires, H. A., Terry, S., & Gleaton, J. (1993). The influence of macro and micro-level cognitive strategies training on text learning. *Journal of Research and Development in Education*, *26*(3), 164–178.

Guthrie, J. T., Van Meter, P., Hancock, G. R., Alao, S., Anderson, E., & McCann, A. (1998). Does concept-oriented reading instruction increase strategy use and conceptual learning from text? *Journal of Educational Psychology*, *90*(2), 261–278.

Guthrie, J. T., Wigfield, A., Barbosa, P., Perencevich, K. C., Taboada, A., Davis, M. H., et al. (2004). Increasing reading comprehension and engagement through concept-oriented reading instruction. *Journal of Educational Psychology*, *96*(3), 403–423.

Hasselhorn, M., & Maehler, C. (1992). Kategorisierungstraining bei Grund- und Sonderschuelern (L): Zur Rolle metamemorialer Instruktionselemente (Training organizational strategies in learning disabled and normal children: The role of metamnemonic instruction). *Psychologie in Erziehung und Unterricht*, *3*(3), 179–189.

Hoek, D., Terwel, J., & van den Eeden, P. (1997). Effects of training in the use of social and cognitive strategies: An intervention in secondary mathematics in co-operative groups. *Educational Research and Evaluation: An International Journal on Theory and Practice*, *3*(4), 364–389.

Hoek, D., van den Eeden, P., & Terwel, J. (1999). The effects of integrated social and cognitive strategy instruction on the mathematics achievement in secondary education. *Learning and Instruction*, *9*(5), 427–448.

Hogan, K. (1999). Thinking aloud together: A test of an intervention to foster students' collaborative scientific reasoning. *Journal of Research in Science Teaching*, *36*(10), 1085–1109.

Hohn, R. L., & Frey, B. (2002). Heuristic training and performance in elementary mathematical problem solving. *The Journal of Educational Research*, *95*(6), 374–380.

Huffman, D. (1997). Effect of explicit problem solving instruction on high school students' problem-solving performance and conceptual understanding of physics. *Journal of Research in Science Teaching*, *34*(6), 551–570.

Kernaghan, K., & Woloshyn, V. E. (1995). Providing grade one students with multiple spelling strategies: Comparisons between strategy instruction, strategy instruction with metacognitive information, and traditional language arts. *Applied Cognitive Psychology*, *9*(2), 157–166.

Kettmann Klingner, J., Vaughn, S., & Schumm, J. S. (1998). Collaborative strategic reading during social studies in heterogeneous fourth-grade classrooms. *Elementary School Journal*, *99*(1), 3–22.

Klauer, K. J. (1993). Über den Einfluss eines Trainings zum induktiven Denken auf den Erwerb und die Nutzung der Lernstrategie des "Networking". *Zeitschrift fuer Entwicklungspsychologie und Paedagogische Psychologie*, *25*(4), 333–352.

Klauer, K. J. (1996a). Teaching inductive reasoning: Some theory and three experimental studies. *Learning and Instruction*, *6*(1), 37–57.

Klauer, K. J. (1996b). Begünstigt induktives Denken das Lösen komplexer Probleme? Experimentelle Studien zu Leutners Sahel-Problem. [Does inductive reasoning promote complex problem-solving: Experimental studies on Leutner's geography computer simulation.]. *Zeitschrift fuer Experimentelle Psychologie*, *43*(1), 85–113.

Klauer, K. J. (1998). Beguenstigt induktives Denken den Erwerb der Gedaechtnisstrategie des Kategorisierens? [Does inductive reasoning foster the acquisition of the memory strategy of clustering?]. *Zeitschrift fuer Paedagogische Psychologie*, *12*(1), 73–84.

Kolic-Vehovec, S. (2002). Self-monitoring and attribution training with poor readers. *Studia Psychologica*, *44*(1), 57–68.

Kramarski, B. (2004). Making sense of graphs: Does metacognitive instruction make a difference on students' mathematical conceptions and alternative conceptions? *Learning and Instruction*, *14*(6), 593–619.

Loranger, A. L. (1997). Comprehension strategies instruction: Does it make a difference? *Reading Psychology*, *18*(1), 31–68.

Lucangeli, D., Galderisi, D., & Cornoldi, C. (1995). Specific and general transfer effects following metamemory training. *Learning Disabilities Research and Practice*, *10*(1), 11–21.

Mason, L. H. (2004). Explicit self-regulated strategy development versus reciprocal questioning: Effects on expository reading comprehension among struggling readers. *Journal of Educational Psychology*, *96*(2), 283–296.

Mevarech, Z. R. (1999). Effects of metacognitive training embedded in cooperative settings on mathematical problem solving. *The Journal of Educational Research*, *92*(4), 195–205.

Mevarech, Z. R., & Kramarski, B. (2003). The effects of metacognitive training versus worked-out examples on students' mathematical reasoning. *British Journal of Educational Psychology*, *73*(4), 449–471.

Schober, B., & Ziegler, A. (2001). Das Muenchner Motivationstraining (MMT): Theoretischer Hintergrund, Foerderziele und exemplarische Umsetzung (The Munich motivational training: Theoretical background, aims and a first evaluation). *Zeitschrift fuer Paedagogische Psychologie*, *15*(3–4), 168–180.

Schreblowski, S., & Hasselhorn, M. (2001). Zur Wirkung zusaetzlicher Motivaenderungskomponenten bei einem metakognitiven Textverarbeitungstraining (On the effectiveness of a motive modification supplement to a metacognitive reading program). *Zeitschrift fuer Paedagogische Psychologie*, *15*(3–4), 145–154.

Schunk, D. H., & Swartz, C. W. (1993). Goals and progress feedback: Effects on self-efficacy and writing achievement. *Contemporary Educational Psychology*, *18*(3), 337–354.

Souvignier, E., & Mokhlesgerami, J. (2006). Using self-regulation as a framework for implementing strategy instruction to foster reading comprehension. *Learning and Instruction*, *16*(1), 57–71.

Sovik, N., Heggberget, M., & Samuelstuen, M. (1996). Strategy-training related to children's text production. *British Journal of Educational Psychology*, *66*(2), 169–180.

Vauras, M., Kinnunen, R., & Rauhanummi, T. (1999). The role of metacognition in the context of integrated strategy intervention. *European Journal of Psychology of Education*, *14*(4), 555–569.

Veenman, S., Beems, D., Gerrits, S., & Op de Weegh, G. (1999). Implementation effects of a training program for self-regulated learning. *Journal of Research and Development in Education*, *32*(3), 148–159.

Verschaffel, L., De Corte, E., Lasure, S., Van Vaerenbergh, G., Bogaerts, H., & Ratinckx, E. (1999). Learning to solve mathematical application problems: A design experiment with fifth graders. *Mathematical Thinking and Learning*, *1*(3), 195–229.

Williams, W. M., Blythe, T., White, N., Li, J., Gardner, H., & Sternberg, R. J. (2002). Practical intelligence for school: Developing metacognitive sources of achievement in adolescence. *Developmental Review*, *22*(2), 162–210.

Wong, R. M. F., Lawson, M. J., & Keeves, J. (2002). The effects of self-explanation training on students' problem solving in high-school mathematics. *Learning and Instruction*, *12*(2), 233–262.