Self-Regulated Learning Training Programs Enhance University Students' Academic Performance, Self-Regulated Learning Strategies, and Motivation: A Meta-Analysis

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Abstract

The present meta-analysis tested the effects of extended self-regulated learning training programs on academic performance, self-regulated learning strategies, and motivation of university students. The literature search revealed 49 studies (5,786 participants) that met the inclusion criteria. A three-level meta-analysis based on 251 effect sizes revealed an overall effect size of $g = .38$. The largest effect sizes were obtained for metacognitive strategies ($g = .40$) and resource management strategies ($g = .39$) followed by academic performance ($g = .37$), motivational outcomes ($g = .35$), and cognitive strategies ($g = .32$). Training effects varied for specific self-regulated learning strategies and ranged between .23 (rehearsal) and .61 (attention and concentration). Moderator analyses revealed differential training effects depending on course design characteristics: Feedback predicted larger training effects for metacognitive and resource management strategies as well as motivation. Cooperative learning arrangements predicted larger training effects for cognitive and metacognitive strategies. The provision of learning protocols predicted larger training effects for resource management strategies. Moreover, training programs based on a metacognitive theoretical background reported higher effects sizes for academic achievement compared to training programs based on cognitive theories. Further, training programs that targeted older students and students with lower prior academic achievement showed larger effect sizes for resource management strategies. To conclude, self-regulated learning training programs enhanced academic performance, self-regulated learning strategies, and motivation of university students.

Keywords: self-regulated learning, learning strategies, training, academic performance, motivation, meta-analysis, higher education

Highlights

- The meta-analysis tested the effects of self-regulated learning (SRL) trainings.
- SRL trainings improved university students’ academic performance.
- SRL trainings improved various (meta-) cognitive and resource management strategies.
- SRL trainings enhanced students’ motivation – especially self-efficacy.
- Training design and student characteristics moderated training effects.

Self-Regulated Learning Training Programs Enhance University Students' Academic Performance, Self-Regulated Learning Strategies, and Motivation: A Meta-Analysis

Self-regulated learning (SRL) constitutes a key competence that lays the foundation for lifelong learning (Dent & Koenka, 2016). SRL is described as a dynamic process whereby learners personally activate and sustain cognitions, affects, and behaviors that are systematically oriented toward the attainment of personal goals (Zimmerman & Schunk, 2011). SRL is especially important in higher education because university students are required to self-organize their studying (Broadbent, 2017; Broadbent & Poon, 2015). University students with better SRL strategies show better academic performance (Richardson, Abraham, & Bond, 2012; Schneider & Preckel, 2017), are more satisfied with their studies (Liborius, Bellhäuser, & Schmitz, 2019), can cope more easily with the transition from school to university (Park, Edmondson, & Lee, 2012), and might be less likely to drop out of their studies (Lowe & Cook, 2003). However, many university students have difficulties to self-regulate their learning (Peverly, Brobst, Graham, & Shaw, 2003). For instance, students frequently don't know effective learning strategies (Bjork, Dunlosky, & Kornell, 2013) or show deficits in time and study management (Steel, 2007). Hence, there is a high demand for training programs to foster SRL among university students.

SRL training programs are assumed to foster academic performance, SRL strategy use, and motivation of university students. Hence, the first goal of the present meta-analysis was to test the effectiveness of SRL training programs for university students. The present meta-analysis, thereby, adds to the results of previous meta-analyses (Hattie, Biggs, & Purdie, 1996; Jansen, van Leeuwen, Janssen, Jak, & Kester, 2019) by testing the effectiveness of SRL training programs for specific SRL strategies (e.g., planning strategies and effort management) and motivational aspects (e.g., self-efficacy). The second goal was to examine characteristics of the training design and student characteristics as moderators of training effectiveness. Building on the results, directions for further research on SRL training programs are discussed.

Self-Regulated Learning Models and Strategies

Models of SRL share the idea that SRL includes different subprocesses and phases (see Panadero, 2017; Puustinen & Pulkkinen, 2001, for a review). Broadly speaking, learning sessions can be divided into three phases: a preparatory phase, a performance phase, and an appraisal phase (Panadero, 2017). In the preparatory phase, learners analyze the task and set goals. During the performance phase, learners monitor and control their goal progress. In the appraisal phase, learners reflect on their goal achievement and adapt their learning strategies for the subsequent study session. Hence, SRL constitutes a dynamic, cyclical process.

Learners use various strategies to regulate their studying, which can be broadly classified as cognitive strategies, metacognitive strategies, and resource management strategies (see Table 1 for a detailed overview). **Cognitive strategies** facilitate information processing and subsume various strategies, such as rehearsal, elaboration, and organization (Weinstein & Mayer, 1985). Cognitive strategies serve to acquire and organize knowledge and to integrate new information into existing knowledge structures. **Metacognitive strategies** refer to second-order cognitions serving to monitor and to control the application of cognitive strategies (Flavell, 1979; Pintrich, Smith, Garcia, & McKeachie, 1991). Metacognitive strategies are applied in all phases of the learning process and encompass goal setting and planning (preparatory phase), monitoring (performance phase), and reflection (appraisal phase). **Resource management strategies** refer to the regulation of internal (attention, concentration, effort, or motivation) and external resources (learning environment, time and study management) (Pintrich, 1999). Resource management strategies are applied to initiate and to maintain learning processes, and to avoid distractions and procrastination (Corno, 2006; Kuhl, 1985; Pintrich, 1999; Wolters, 2003). Taken together, self-regulated learners apply a multitude of cognitive, metacognitive, and resource management strategies throughout the learning process.

SRL models further emphasize the importance of students' motivation for SRL processes (e.g., Zimmerman, 2000). For instance, self-efficacy, goal orientation, and task value beliefs guide students' choice of learning strategies (Liem, Lau, & Nie, 2008; Wigfield & Eccles, 2000). Students' motivation is thus considered as an outcome variable in this meta-analysis.

Self-Regulated Learning Training Programs: Previous Meta-Analytic Findings

The current meta-analysis focusses on extended SRL training programs that were conducted in real classrooms. Extended SRL training programs typically include multiple training sessions and cover a direct instruction of cognitive, metacognitive, and/or resource management strategies. Extended SRL training programs are usually conducted within a group of students and span several days or weeks. In this regard, extended SRL training programs differ from one-time laboratory experiments where students typically practice only a few strategies and training effects are evaluated directly after the laboratory session in well-controlled experimental tasks.

Previous meta-analytic research demonstrated positive effects of extended SRL training programs on academic performance, SRL strategy use, and motivation. For instance, Dignath and Büttner (2008) reported positive effects of SRL training programs on academic performance, SRL strategy use, and motivation for primary (g = .68) and secondary (g = .71) school children. Further, SRL training programs have been shown to improve academic performance in various domains (e.g. reading (g = .36), writing (g = 1.25), mathematics (g = .66), and science (g = .73);

Donker, de Boer, Kostons, Dignath van Ewijk, & van der Werf, 2014). Another meta-analysis revealed positive long-term effects of SRL training programs on academic performance (g = .63, de Boer et al., 2018). However, these meta-analyses focused on primary and secondary school children and did not test the effectiveness of SRL training programs for university students.

The effectiveness of SRL training programs has also been tested for university students. For instance, Hattie, Biggs, and Purdie (1996) showed that study skill trainings improved students' academic performance (g = .27), general study skills (g = .17), and affective outcomes (e.g., motivation and self-concept, g = .68). This meta-analysis was, however, based on primary studies that were published by 1993 and only included 18 studies that tested higher education students. Furthermore, around the year 2000, several influential models of SRL (e.g., Boekaerts, 1999; Pintrich, 1999; Winne & Hadwin, 1998; Zimmerman, 2000) inspired new SRL training approaches that focused more on metacognitive reflection and motivational aspects of learning (see Paris & Paris, 2001 for an overview of the development of SRL training approaches). Moreover, the majority of studies included in this meta-analysis tested exceptional students, i.e., students with either very low or very high previous academic achievement. Hence, results cannot be easily applied to regular-performing students. Taken together, there is a need for testing the effectiveness of SRL training programs using a larger data base that includes more recent training approaches and more diverse student samples.

Another meta-analysis tested the effectiveness of SRL interventions for university students (Jansen et al., 2019). The meta-analysis included 51 studies that tested the effects of SRL interventions on performance, and 32 studies that tested the effects of SRL interventions on SRL activities. SRL interventions subsumed SRL training programs but also interventions without direct strategy instruction, such as instructional prompts (e.g., Bannert & Reimann, 2012). Results revealed that SRL interventions improved university students' academic performance (d = .49) and SRL activity (d = .50). Results further revealed a partial mediation: SRL interventions fostered SRL activities which, in turn, improved academic performance. SRL activities, thereby, subsumed several SRL strategies, i.e., cognitive, metacognitive, and resource management strategies. That is, this meta-analysis did not distinguish between effects of SRL training programs for specific SRL strategies, such as organization, planning, or effort management. Specific SRL strategies differ in their importance for academic performance in higher education, however. For example, several meta-analyses revealed that an efficient management of effort, time, and study environment was strongly related to academic performance in higher education (Broadbent & Poon, 2015; Richardson et al., 2012; Sitzmann & Ely, 2011). In contrast, cognitive strategies such as rehearsal or elaboration were only moderately related to academic performance. In other words, resource management strategies seem to be particularly important for university students' academic performance. Hence, if the goal is to improve the academic achievement of university students, SRL training programs should promote effective strategies, such as effort regulation or time management. Therefore, the current meta-analysis aimed to provide a more differentiated view on the effects of SRL training programs for specific SRL strategies.

Besides, previous meta-analyses did not test the effects of SRL training programs on specific aspects of students' motivation. Students' motivation is determined by control beliefs, such as self-efficacy, as well as value beliefs, such as task value or interest (Wigfield & Eccles, 2000; see Table 1 for definitions). Hattie et al. (1996) tested whether SRL training programs improved affective outcomes which subsumed self-efficacy and self-concept. However, this average effect size was based on only 11 primary studies and did not differentiate between control and value aspects of motivation. Both control and value beliefs play an important role in SRL because they guide the choice of SRL strategies (Liem et al., 2008; Zimmerman, 2000). Hence, students' motivation constitutes an integral part of SRL (Pintrich, 1999; Schunk & DiBenedetto, 2020). Further, students' motivation is positively linked to academic performance in higher education (e.g., Richardson et al., 2012; Sitzmann & Ely, 2011). Given the high relevance of motivation for SRL and academic performance, it is important to test whether SRL training programs enhance students' motivation.

Taken together, the first aim was to test the effects of SRL training programs on academic performance, SRL strategies, and motivation. Previous meta-analyses were based on a small number of primary studies (Hattie et al., 1996), or did not examine the effects of SRL trainings on motivation, nor specific SRL strategies (Jansen et al., 2019). A more differentiated view on the effects of SRL training programs on specific motivational aspects and SRL strategies was thus needed. This meta-analysis adds to the results of previous meta-analyses (1) by testing the effects of SRL training programs on motivation, and (2) by analyzing differential effects of SRL training programs for specific SRL strategies.

Moderators of Training Effectiveness

A second goal of the current meta-analysis was to identify moderators of SRL training effectiveness. A recent meta-analysis revealed that several study characteristics did not moderate training effects (e.g., academic subject of the participants, study setting (online/offline), quality of the study design) (Jansen et al., 2019). Results further revealed that several intervention characteristics did not moderate training effects (e.g., timing of the intervention, whether the course was tailored to the learning context, or which set of SRL strategies were taught). Hence, the current meta-analysis focused on a different set of moderators to add to the previous findings.

Two sets of moderators were coded. The first group of moderators encompassed factors related to the design of the training program (i.e., whether the training encompassed feedback, cooperative learning arrangements, and/or learning protocols), and theoretical background of the training program. These variables were coded to inform teachers on the effective design of SRL training programs. The second group of moderators encompassed student characteristics (age and achievement status). Student characteristics were coded to identify students who might especially benefit from SRL interventions.

Design of SRL training program. Deficits in self-regulated learning can originate from an availability or a production deficiency (Veenman, Van Hout-Wolters, & Afflerbach, 2006). In case of an availability deficiency, the learner lacks knowledge about effective SRL strategies. In case of a production deficiency, the learner does not know when or how to apply a certain strategy. SRL training programs oftentimes focus on teaching various SRL strategies to increase the strategy repertoire, i.e., to reduce availability deficits. However, to overcome production deficits, training programs should support the transfer of SRL strategies to daily life. For instance, it has been shown that prompting students to make strategic use of their learning resources promoted academic achievement (Chen, Chavez, Ong, & Gunderson, 2017). Similarly, meta-analyses revealed that SRL training programs were more effective if they promoted metacognitive reflection (Dignath & Büttner, 2008; Donker et al., 2014): School children improved their SRL strategies and performance more if they were taught when, why, and how they should use certain SRL strategies. Hence, self-reflection about the appropriate use of learning strategies was expected to benefit training effectiveness. Moderator variables, thus, included training design characteristics that were expected to support metacognitive reflection.

Feedback. Effective feedback provides information on goals, current performance related to goals, and suggestions about how to close the gap between goals and current performance (Hattie & Timperley, 2007; Wisniewski, Zierer, & Hattie, 2020). Feedback can thus support SRL by invoking task analysis, monitoring, and strategy selection (Butler & Winne, 1995). Feedback that informs learners about the appropriate choice and regulation of learning strategies seems especially promising (i.e., self-regulation feedback, see Hattie & Timperley, 2007; Wisniewski et al., 2020 for an overview). Self-regulation feedback can, for instance, encompass strategic hints on how to monitor or adapt learning strategies (Wisniewski et al., 2020). Training programs are thus assumed to be more effective if teachers provide self-regulation feedback.

Cooperative learning. In cooperative learning arrangements, students share responsibilities, ideas, and thoughts which is assumed to promote metacognitive reflection and motivation (Chiu & Kuo, 2009). However, previous meta-analytical research provided inconclusive results on whether cooperative learning benefits SRL training effectiveness. It has been found that training programs that included cooperative learning arrangements were equally effective as or even less effective than training programs without cooperative learning arrangements (de Boer et al., 2018; de Boer, Donker, & van der Werf, 2014; Dignath & Büttner, 2008). However, cooperative learning has been tested as a moderator for primary and secondary school children. It has remained unclear whether the findings applied to training programs that target university students.

Learning protocols. Learning protocols are assumed to promote monitoring and reflection. Learning protocols (sometimes also called learning diaries, goal sheets, or study logs) encourage students to report their application of SRL strategies, study times, or goals on a regular basis (e.g., daily or weekly). Learning protocols can function as study reminders and are assumed to stimulate goal setting, monitoring, and reflection (Panadero, Klug, & Järvelä, 2016; Schmitz & Wiese, 2006). That is, students can easily self-evaluate their learning progress which has been shown to boost SRL and motivation (Panadero, Jonsson, & Botella, 2017). The inclusion of learning protocols has thus been assumed to benefit training effectiveness.

Theoretical background. SRL training programs differ in their theoretical background. Study skill trainings (e.g., Dansereau et al., 1983; Weinstein & Mayer, 1986) are based on cognitive theories and typically focus on teaching strategies that are directly related to a specific academic task, e.g., reading strategies, note taking, preparing for exams, or dealing with test anxiety. That is, the main focus of study skill trainings is the instruction of cognitive strategies and resource management strategies. SRL training programs based on metacognitive theories (e.g., Flavell, 1979) typically focus on teaching various metacognitive strategies and metacognitive reflection, e.g., planning, monitoring, and evaluation of learning outcomes, and only rarely cover resource management strategies. Training programs based on social-cognitive theories (e.g., Zimmerman, 2002) emphasize motivational aspects of learning. Those trainings focus more on the instruction of resource management as compared to cognitive strategies, and further encourage metacognitive reflection on learning processes. Hence, depending on the theoretical background, training programs emphasize different aspects of self-regulated learning and groups of strategies.

A previous meta-analysis revealed that the theoretical background of the training program moderated training effects on academic achievement for secondary school children (Dignath & Büttner, 2008). Training programs based on metacognitive theories reported higher training effects on academic achievement compared to training programs based on social-cognitive or motivational theories. Therefore, theoretical background of the training program was tested as a moderator of training effects on academic achievement in this meta-analysis. Note that theoretical background was initially coded as a descriptive variable. The decision to use this variable as a moderator was made post-hoc without having a directed hypothesis.

Student characteristics.

Age. Hattie et al. (1996) found that university students benefited less from training programs regarding their SRL strategies compared to school children. The authors argued that young learners are malleable regarding their learning strategies while higher education students may have already consolidated their strategies. On the other hand, many university students struggle after the transition from school to university due to the increase in self-regulatory demands (see Vosniadou, 2020 for a review). Therefore, university students may particularly benefit from SRL training programs at the beginning of their studies. Thus, students' age was tested as a moderator of training effectiveness.

Prior academic achievement. SRL training programs often target students with below-average university grade point average (GPA), e.g., underachieving students, students on academic probation, or *at-risk* students. However, previous meta-analyses provided mixed evidence regarding the effectiveness of SRL training programs for underachieving students: One meta-analysis revealed that underachieving students benefitted from most training programs compared to average performers or high-ability students (Hattie et al., 1996). Another meta-analysis, however, did not find differential effects for underachieving students (Donker et al., 2014). It is thus unclear whether underachieving students especially benefit from SRL training programs.

The Present Meta-Analysis

SRL strategies are crucial for university success (Broadbent & Poon, 2015; Richardson et al., 2012). However, previous meta-analyses that tested the effectiveness of SRL training programs focused on school children (e.g., Dignath & Büttner, 2008), university students with very high or very low prior academic achievement (Hattie et al., 1996), or a broader range of tertiary students, i.e., including participants in vocational training or in workplace learning (Jansen et al., 2019). Further, a detailed account of the effect of SRL training programs for specific SRL strategies and motivational aspects was missing. Hence, the first aim of this meta-analysis was to provide an overview of the effects of SRL training programs for university students' motivation and specific SRL strategies.

A second goal was to examine moderators of training effectiveness. The first group of moderators encompassed factors related to the design of the training program (i.e., feedback, cooperative learning, and learning protocols). The second group of moderators encompassed student characteristics (i.e., age and prior academic achievement). Moderator variables were chosen to inform teachers on the effective design of SRL training programs, and to find out which students might especially benefit from SRL interventions.

A third goal was to provide avenues for further research on SRL training programs. The discussion therefore reviews (1) alternative ways to assess SRL training effects and (2) adaptive training approaches to foster SRL depending on the situation and students' prerequisites.

Method

The meta-analysis followed the PRISMA guidelines for reporting meta-analytical findings PRISMA (Moher, Liberati, Tetzlaff, & Altman, 2009). The coding scheme, an overview of studies tested for eligibility, the data and the data analysis script are available via the Open Science Framework (https://osf.io/u6szn/).

Literature Search

A systematic literature search was carried out via the online databases PsycINFO, ERIC, PsycARTICLES, and PSYNDEX in November 2018 and it was updated in January 2021. The following search terms were used:

abstract:("intervention" OR "training" OR "treatment" OR "foster*") AND abstract:("university" OR "college" OR "undergraduates" OR "undergraduate" OR "graduate" OR "graduates" OR "high* education" OR "post-secondary education") AND abstract:("study skills" OR "learning strategies" OR "self-regulatory strategies" OR "self-regulatory skills" OR "metacognition" OR "metacognitive skills" OR "metacognitive strategies" OR "time management" OR "resource strategies" OR "self-regulated learning" OR "motivational skills" OR "self-motivation" OR "study habits" OR "learning style" OR "cognitive strategies"). Further, backward and forward search was conducted to detect additional literature.

The literature search encompassed published and unpublished literature written in English or German recorded by January 2021. The literature search encompassed published studies and gray literature of unpublished studies. Only gray literature that was indexed (i.e., traceable using online data bases) was included because including literature that has never entered the publication process can increase the risk of bias in meta-analyses (Chow & Ekholm, 2018).

Criteria for Inclusion and Exclusion

Firstly, training programs had to target SRL and had to include direct strategy instruction; training programs encompassed a direct strategy instruction of cognitive, metacognitive, or resource management strategies. Studies without explicit strategy instruction that supported SRL processes indirectly (e.g., by providing prompts without direct strategy instruction) or through instructional practices (e.g., by implementing cooperative learning arrangements) were excluded. These indirect interventions did not inform students about SRL strategies or how to apply SRL strategies. As this meta-analysis aimed to test the effectiveness of informed SRL trainings, this restriction served to enhance the comparability across training studies. Further, only extended SRL training programs (conducted in real classrooms) were included to distinguish between training programs and one-time experiments.

Moreover, training programs had to target university students (on campus or distance education). Training studies that tested school children, workers, trainees, or students suffering from learning disabilities were excluded.

Studies had to report sufficient information to compute effect sizes (*N*, *M*, *SD*). If information on means and standard deviations was not available, effect sizes were computed based on the respective *F*-values of the interaction term of group (control vs. training) and time (pre vs. post training).

Only studies using experimental or quasi-experimental pre-post control group designs were included. This was done to assure a comparable methodological standard and to reduce the problem of *garbage in garbage out*. If pretest means were not reported, studies were only included if they had tested that there were no significant differences between groups before starting the training. Moreover, samples had to include at least ten participants per group to assure that effect sizes were approximately normally distributed (Hedges & Olkin, 1985).

Finally, studies had to report at least one of five outcome measures: students' academic performance, cognitive strategies, metacognitive strategies, resource management strategies, or motivational outcomes.

Selection of Studies

Figure 1 shows the flow diagram for the literature selection process. Initially, 1,567 articles were identified from database search (*n* = 1,512) or through backward and forward search of literature (*n* = 55). After removing duplicates (*n* = 472), 1095 articles were screened for eligibility based on title, abstract, and keywords. Of those, 669 articles were rejected – mostly because they did not target SRL of university students or because they did not include a training program. The remaining 396 studies entered a detailed evaluation. Of those, 125 articles did not meet the inclusion criteria for SRL training programs defined in this meta-analysis. They targeted, for instance, learning styles or fostered SRL indirectly via course instruction. Another 91 studies did not implement a pre-post design, or did not include a control group. 44 studies reported insufficient information to compute effect sizes. Another 47 articles were either not accessible or not written in English or German. The remaining studies excluded at this stage did not include empirical data (*n* = 18) or did not test university students (*n* = 22). Hence, 49 studies met all inclusion criteria and were included in the meta-analysis.

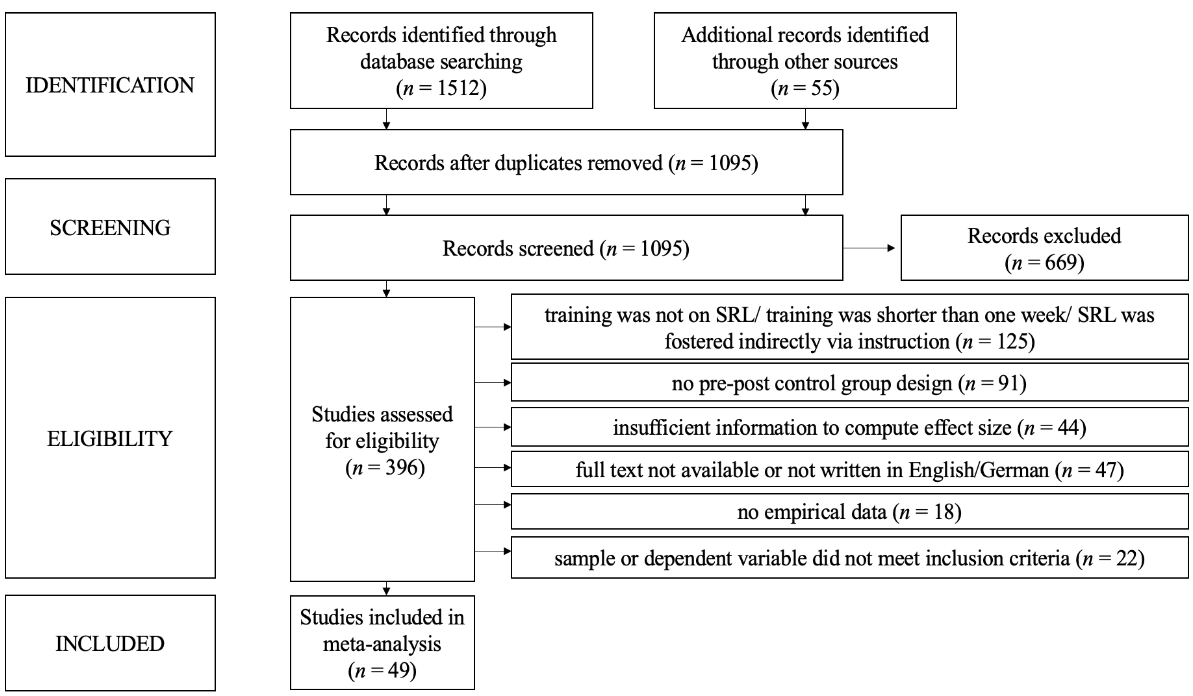

Figure 1. Literature selection process.

Coding of Outcome Categories

Five higher-level outcome categories were defined: academic performance, cognitive strategies, metacognitive strategies, resource management strategies, and motivational outcomes. All outcome categories subsumed several lower-level outcome categories (see Table 1 for a detailed overview). Apart from academic performance, most outcome measures were assessed using retrospective self-report questionnaires. Metacognitive knowledge was assessed using knowledge tests. Further, four studies (Bernacki, Vosicka, & Utz, 2020; Bernacki, Vosicka, Utz, & Warren, 2020; Biwer, Egbrink, Aalten, & de Bruin, 2020; Cogliano, Bernacki, & Kardash, 2020) used log-file data to assess students' metacognitive or cognitive strategy use.

Table 1

Overview of Outcome Measures Included in the Meta-Analysis

Outcome Measure	Definition & Examples
Academic Performance	
Test Performance	Academic performance in standardized tests assessing knowledge in a narrowly defined subject or performance in a course examination. Example: Students attended a language tutorial and were tested regarding their language skills before and after the course.
Grade Point Average (GPA)	Grade point average (GPA) that comprises grades from various subjects and courses that were not directly related to the SRL training program.
Cognitive Strategies	
Rehearsal/ Memorizing	Learners repeat, restudy, or memorize learning materials after initial studying (see MSLQ, Pintrich et al., 1991 for example items).
Elaboration	Learners generate examples that go beyond the information provided or learners link new content to prior knowledge. Examples: Paraphrasing or creating analogies (see MSLQ, Pintrich et al., 1991 for example items)

Organization	Learners identify, structure, or organize the main learning content. Examples: Outlining or selecting main ideas (see MSLQ, Pintrich et al., 1991 for example items)
Cognitive Strategies (composite measure)	Several learning strategies are assessed in one composite measure. Example: Information Processing (see LASSI; Weinstein, Palmer, & Acee, 2016 for example items); The scale assesses how well students use imagery, verbal elaboration, organization strategies, and reasoning skills.
Metacognitive Strategies	
Planning & Goal setting	Learners think about what they need to learn, set task-specific goals, and choose appropriate strategies to achieve their goals. Examples: Generating a study schedule or setting a learning goal (see MAI, Schraw & Dennison, 1994 for example items)
Monitoring	Learners keep track of their current goal progress, knowledge, or understanding of the course material. Example: Comprehension monitoring (see MAI, Schraw & Dennison, 1994 for example items)
Reflection	Learners reflect about learning processes or their goal achievement after learning. Example: Evaluation (see MAI, Schraw & Dennison, 1994 for example items)
Metacognitive self-regulation (composite measure)	Several metacognitive strategies are assessed in one composite measure. Example: Metacognitive self-regulation (see MSLQ, Pintrich et al., 1991 for example items). The scale assesses learners' planning strategies, monitoring, and metacognitive regulation.
Knowledge about strategies	Knowledge tests assess either declarative knowledge about strategies (e.g., Rosário et al., 2010; 2015) and/or procedural knowledge on the appropriate application of strategies (e.g., using situational judgement tests, see e.g., Biwer et al., 2020).
Resource Management	
Attention / Concentration	Learners' ability to maintain their cognitive focus and to concentrate during learning. Example: Concentration (see LASSI; Weinstein, Palmer, & Acee, 2016 for example items)
Effort Management /	Learners' ability to control their effort and to persist on a task

Persistence	even when they are facing difficulties or distractions. Example: Effort regulation (see MSLQ, Pintrich et al., 1991 for example items) or delay avoidance (see SSHA, Holtzman, Brown, & Farquhar, 1954 for example items)
Motivation Regulation Strategies	Learners' ability to initiate, maintain, or enhance their level of motivation (Wolters, 2003). Example: Interest enhancement or self-instruction (see Wolters & Benzon, 2013 for example items)
Time and Study Management	Learners' ability to manage and to regulate their time and study environment. Learners organize their study environment to avoid distractions during learning. Example: Time and Study Environment (see MSLQ, Pintrich et al., 1991 for example items) or work methods (see SSHA, Holtzman et al., 1954 for example items)
Motivational outcomes	
Intrinsic Value & Goal Orientation	Learners' valuing of the task for its own merits (intrinsic value), and learners' valuing of the process of learning for its own merits (goal orientation) (see Zimmerman, 2002). Example: Intrinsic (vs. extrinsic) goal orientation (see MSLQ, Pintrich et al., 1991 for example items)
Self-Efficacy	Learners' beliefs about having the personal capability to regulate learning (Bandura, 1991). Example: Self-efficacy for self-regulated learning (see Usher & Pajares, 2008 for example items)

Note. MSLQ = Motivated strategies for learning questionnaire, LASSI = Learning and Study Strategies Inventory, MAI = Metacognitive Awareness Inventory. SSHA = Survey of Study Habits and Attitudes.

Coding of Moderator Variables

Moderator variables were coded by two coders according to a coding scheme (first author and a trained student assistant). The average interrater agreement was 92% (*SD* = .043, [.88; 1.00]). Discrepancies were resolved by discussion and by reevaluating the information.

Design of SRL training program. Three aspects of training design were coded. First, we coded whether the teacher provided feedback to students. Teacher feedback could target students' application of learning strategies and/or students' current course performance or learning progress. We then coded whether the training included cooperative learning arrangements. For instance, students worked on a shared task, and/or engaged in group discussions on the appropriate application of learning strategies, and/or received and provided peer feedback. Third, we coded whether the training programs included learning protocols, such as daily or weekly time tables, study logs, goal sheets, or learning diaries.

Moreover, theoretical background of the training program was coded. This was done to account for differences in training content based on the theoretical background of the training program. Three types of trainings were identified: (1) Study skill trainings, (2) metacognitive trainings, and (3) social-cognitive trainings. A training was classified as a study skill training if it was based on cognitive learning theories and focused on teaching cognitive and resource management strategies that were directly related to a specific academic task, e.g., reading strategies, note taking, preparing for exams, or dealing with test anxiety (cf. Weinstein & Mayer, 1985). A training was classified as a metacognitive training if it was based on metacognitive theories (e.g., Flavell, 1979) and focused on metacognitive strategy instruction, e.g., planning, monitoring, evaluation, and metacognitive reflection. A training was classified as a social-cognitive training if it was based on social-cognitive theories (e.g., Zimmerman, 2002) and focused on the instruction of resource management strategies and metacognitive reflection. Note that the decision to test theoretical background as a moderator was made post-hoc without having a directed hypothesis.

Student characteristics. Students' mean age (in years) was coded as a continuous moderator variable. Furthermore, we coded whether the training program especially targeted students with below-average previous academic achievement. Information about previous academic achievement was derived from the studies' sample descriptions. That is, these studies explicitly stated in the sample description that the training targeted underachieving students. Underachieving students were defined as students with below-average scholastic assessment test scores (SAT) or high school GPA, students under academic probation, or students at-risk of dropping out of university.

Effect Size Coding

First, Cohen's *d* was computed by dividing the difference of mean improvement between training group and control group by the pooled pretest *SD*. Pooled pretest *SD*s were calculated as the square-root of the degrees-of-freedom weighted mean variance of both groups. To control for small sample bias, Cohen's *d* and Var_d were transformed into Hedges' *g* and Var_g using a correction factor (Borenstein, Hedges, Higgins, & Rothstein, 2009). If studies only reported posttest data but showed that there were no preexisting differences between groups, post-standardized mean differences between training and control group were computed (Hedges & Olkin, 1985). Whenever possible, means, standard deviations, and sample sizes were used for effect size calculation. If the authors only reported *F*-values, the effect gain was estimated by taking the square root of the product of the *F*-value and the sum of the overall sample size divided by the product of the sample size of the control and training group (see Borenstein et al., 2009). All effect sizes were transformed into a common metric such that higher values indicated larger effect sizes in favor of the training group. In case of multiple outcomes per study, separate effect sizes were computed for each outcome.

Meta-Analytic Procedure: Multi-Level Modelling

Before performing the meta-analysis, several forms of dependency between effect sizes were considered. Dependency between effect sizes can arise if (a) the same study includes multiple samples, (b) several training groups are compared to the same control group, and (c) multiple outcomes are reported within the same study. Treating correlated effect sizes as if they were providing independent, unique information can lead to an incorrect narrowing of the confidence estimates which increases the risk of making type I errors (Van den Noortgate, López-López, Marín-Martínez, & Sánchez-Meca, 2013).

In the current meta-analysis, only 4 studies tested more than one sample (Bernacki, Vosicka, Utz, et al., 2020; Eide, 1999; Rosário et al., 2010, 2015). Hence, it was not possible to estimate the variance between samples within studies. Importantly, the samples comprised separate training and independent control groups. Thus, all 55 samples (originating from 49 studies) were treated as independent samples because dependency among effect sizes was negligible.

Furthermore, 6 studies compared the effects of two different training groups with the same control group (Bellhäuser, 2016; Bellhäuser, Lösch, Winter, & Schmitz, 2016; Dörrenbächer & Perels, 2016a; Fabriz, Dignath-van Ewijk, Poarch, & Büttner, 2014; Richards & Perri, 1978). In these cases, comparisons were limited to the training group that was more central to the research question of the researchers. This simplification limited each study to one single comparison between a training group and a control group per measure.

Most studies reported more than one outcome measure. One way to deal with multiple outcome measures is to aggregate effect sizes within studies. Inevitably, each aggregation leads to a loss of information and statistical power. Three-level meta-analysis constitutes an alternative approach which avoids an aggregation of effect sizes (Van den Noortgate et al., 2013, see *Equation 1*) by modeling the sampling variance for each effect size (level 1), variation over outcomes within a study (level 2), and variation over studies (level 3):

$$d_{kn} = \gamma_{00} + u_{0n} + v_{kn} + r_{kn} \qquad (1)$$

Equation 1 states that d_{kn}, the observed effect size k (k =1, 2,…, K) from study n (n =1, 2, …, N) equals the overall mean effect size (γ_{00}) including systematic variation between studies (u_{0n}), systematic variation between outcomes originating from the same study (v_{kn}), and random deviation due to sampling error (r_{kn}). Hence, *Equation 1* includes two sources of systematic variance that can be modelled in three-level meta-analysis: variance between studies (σ_u^2) and variance between outcomes from the same study (σ_v^2). In a first step, an unconditional model was estimated which included only an intercept (the overall mean effect), estimates of the variation between studies, and the variation between effect sizes within studies. Thereby, the unconditional model reflects a random-effects model that allows variation of effect sizes between studies and between outcomes within studies. In a second step, potential moderators (fixed effects) were added. Hence, moderator variables were used as independent variables in a meta-regression to predict differences in effect sizes between and within studies. Bonferroni-Holm correction was applied to account for multiple testing within each meta-regression (Holm, 1979).

Analyses were performed using R (R Core Team, 2019). Significance levels were set at 0.05 throughout the analyses.

Results

Descriptive Results

Altogether, the meta-analysis included 55 samples (originating from 49 studies) that encompassed 5,786 students. Overall, 252 effect sizes were reported (*M* = 4.56, *SD* = 3.58, range: [1; 13]). Given the 252 effect sizes, 36 (14%; originating from 31 studies) measured performance outcomes, 41 (16%; originating from 18 studies) cognitive strategies, 67 (27%; originating from 29 studies) metacognitive strategies, 59 (23%; originating from 23 studies) resource management strategies, and 49 (19%; originating from 24 studies) measured motivational outcomes. Outlier analysis yielded that one effect size (Seel, 1984; time management) deviated remarkably from the rest of the distribution based on several influence statistics (*DFFITS*, Cook's *D*, studentized deleted residuals). This effect size was thus excluded from further analyses.

Table 2 provides descriptive statistics and correlations among moderator variables. Table 3 gives a descriptive overview of all studies. Correlation analyses revealed that the average age of the participants was significantly related to the provision of feedback. That is, training programs that included teacher feedback tended to have on average younger participants. None of the remaining correlations were significant.

Table 2

Descriptive Statistics and Correlation Analyses

	Moderator variable	# Studies	1	2	3	4
1	Feedback (1 = yes)	*n* = 9				
2	Cooperative Learning (1 = yes)	*n* = 20	-.03			
3	Learning Protocols (1 = yes)	*n* = 18	.11	.04		
4	Age (in years)	*M* = 21.6 *SD* = 2.69	-.33*	-.27	.32	
5	Prior achievement (1 = underachievers)	*n* = 14	-.15	-.09	-.05	-.19

Note. * $p < .05$

Studies = Number of studies that included this moderator variable.

Table 3
Summary of Studies Included in the Meta-Analysis

No.	Authors	*N*	Outcome (# ES)	Age	Under-achiever	Feedback	Cooperative Learning	Learning Protocols	Background/ Training Emphases
1	Bail et al., 2008	157	PF (1)	21.1	yes	Students practiced strategies and received feedback on their attempts.	Students were encouraged to work in groups and to give and receive peer feedback on strategy application.	no	cognitive/ resource strategies
2	Bellhäuser, 2016	68	PF (1), COG (1), META (5), RES (2), MOT (1)	19.8	no	No	Students were encouraged to give and receive feedback on their usage of SRL strategies.	daily [c] standardized pre- & post-learning questionnaires	social-cognitive
3	Bellhäuser et al., 2016	74	PF (1), COG (1), META (4), RES (3), MOT (1)	20.2	no	no	A discussion forum served to encourage students to share their experiences with different strategies with their peers	daily [c] standardized pre- & post-learning questionnaires	social-cognitive

Table 3 *(continued)*

No.	Authors	*N*	Outcome (# ES)	Age	Under-achiever	Feedback	Cooperative Learning	Learning Protocols	Background/ Training Emphases
4	Bernacki et al., 2020a	224	META (3) PF (2)	22.3	no	no	no	no	cognitive/ resource strategies
5a	Bernacki et al., 2020b	128	META (3) PF (1)	21.6	no	no	no	no	cognitive/ resource strategies
5b		149		19.6					
6	Biwer et al.	47	COG (3) META (2)	21.4	no	no	Students share study logs in group and reflect on learning strategy use and study motivation	no	meta-cognitive
7	Broadbent	36	COG (4),	29.7	no	no	no	daily [c]	social-

	et al., 2020		META (2), RES (2), MOT (5)					standardized pre- & post-learning questionnaires	cognitive

Table 3 *(continued)*

No.	Authors	No.	Authors	Age	Under-achiever	Feedback	Cooperative Learning	Learning Protocols	Background/ Training Emphases
8	Ciccocioppo, 2005	43	PF (1)	22.8	yes	no	no	no	cognitive/ resource strategies
9	Cogliano et al., 2020	103	PF (1) META (7)	22.6	no	Students received feedback on how to monitor their strategy use and how they can benefit from monitoring	no	weekly o reflection on intervention effects on their knowledge and regulation of cognition	meta-cognitive
10	Çubukçub, 2008	130	PF (2)	NA	no	Students received feedback on how to set task-specific goals and how to apply SRL strategies	no	no	meta-cognitive

Table 3 *(continued)*

No.	Authors	No.	Authors	Age	Under-achiever	Feedback	Cooperative Learning	Learning Protocols	Background/ Training Emphases
11	Dansereau et al., 1979	59	PF (1), RES (1) MOT (1)	NA	no	no	no	no	cognitive/ resource strategies
12	Dansereau et al., 1983	97	PF (1)	NA	no	no	no	no	cognitive/ resource strategies
13	Davis, 1997	42	RES (1)	NA	yes	no	no	weekly o	social-

			MOT (1)					writing about daily experiences	cognitive
14	Dendato & Diener, 1986	21	PF (1)	19.1	no	no	no	no	cognitive/ resource strategies

Table 3 *(continued)*

No.	Authors	No.	Authors	Age	Under-achiever	Feedback	Cooperative Learning	Learning Protocols	Background/ Training Emphases
15	Dörrenbächer & Perels, 2016	74	COG (1), META (5), RES (2), MOT (4)	22.9	no	no	Students worked in groups on exercises. Students discussed adaptive ways to deal with failure.	daily [c] standardized pre- & post-learning questionnaires	social-cognitive
16a	Eide, 1999	53	PF (1), COG (4), META (1)	20.00	no	Students received feedback on scores in MSLQ and learned ways to improve their strategies	no	no	cognitive/ resource strategies
16b		28		26.8					
17	Fabriz et al., 2014	38	COG (1), META (3), RES (3)	22.5	no	Students received feedback on presentation and on their learning behavior at the end of the term.	Teacher introduced a learning strategy followed by a 60-min presentation of a student group including small group work and group assignments.	twice a week [c] standardized pre- & post-learning questionnaires	social-cognitive

Table 3 *(continued)*

No.	Authors	No.	Authors	Age	Under-achiever	Feedback	Cooperative Learning	Learning Protocols	Background/ Training Emphases

18	Gadzella et al., 1977	160	PF (1) RES (2)	NA	no	no	no	no	cognitive/ resource strategies
19	Ganda & Boruchovitch, 2018	109	COG (2), RES (3), MOT (1)	20.6	no	Students received explicit guidance on how to apply the course content to their own learning and future practice	no	no	social-cognitive
20	Grunschel et al., 2018	106	META (1), RES (4)	25.9	no	Teacher provided feedback on study plans and goals.	Peers provided feedback on study plans and goals.	NA ° creating a to-do list for the next study day	social-cognitive

Table 3 *(continued)*

No.	Authors	*N*	Outcome (# ES)	Age	Under-achiever	Feedback	Cooperative Learning	Learning Protocols	Background/ Training Emphases
21	Hazard, 1998	134	PF (1), MOT (1)	NA	yes	no	no	no	cognitive/ resource strategies
22	Hoops et al., 2015	170	PF (1)	24.0	no	no	no	no	social-cognitive
23	Husni, 2007	60	PF (1)	18.5	yes	no	no	weekly ° reflect about exercises and feelings	cognitive/ resource strategies
24	Kimber, 2009	29	PF (1), COG (1), META (1)	20.5	no	no	Participants were encouraged to work in groups and to discuss ideas and issues related to SRL.	no	social-cognitive

Table 3 *(continued)*

No.	Authors	*N*	Outcome (# ES)	Age	Underachiever	Feedback	Cooperative Learning	Learning Protocols	Background/ Training Emphases
25	Kirkland & Hollandsworth, 1980	25	PF (1) META (1)	NA	no	no	no	no	cognitive/ resource strategies
26	Krauß, 2010	105	META (1), RES (1), MOT (7)	23.3	no	no	Students gave and received peer feedback regarding their strategy use.	daily $_c$ standardized pre- & post-learning questionnaires	social-cognitive
27	Lancaster, 2011	171	MOT (1)	NA	yes	no	no	daily $_o$ reflection exercises	social-cognitive
28	Lu et al., 2017	120	PF (1), COG (2), META (2), RES (1), MOT (2)	19.1	no	no	no	weekly $_o$ report strategy application	social-cognitive

Table 3 *(continued)*

No.	Authors	*N*	Outcome (# ES)	Age	Underachiever	Feedback	Cooperative Learning	Learning Protocols	Background/ Training Emphases
29	Markette, 1996	74	COG (2), META (2), RES (1)	18.4	yes	no	no	no	meta-cognitive
30	McKeachie et al., 1985	221	PERF (2)	NA	yes	no	Groups of students worked on research projects on the development and evaluation of learning strategies.	no	cognitive/ resource strategies
31	Mitchell et al., 1975	30	PERF (2)	19.6	yes	no	no	no	cognitive/ resource strategies

32	Mizumoto & Takeuchi, 2009	146	PF (1), COG (5), RES (1), MOT (2)	NA	no	no	Learners with different types of strategies discussed how they approach certain learning tasks.	daily [o] Study logs;reflection on usefulness of strategies	meta-cognitive

Table 3 *(continued)*

No.	Authors	*N*	Outcome (# ES)	Age	Under-achiever	Feedback	Cooperative Learning	Learning Protocols	Background/ Training Emphases
33	Naveh-Benjamin, 1991	28	PF (1)	NA	no	no	no	no	cognitive/ resource strategies
34	Nguyen & Gu, 2013	91	PF (1), META (4) RES (1)	21.0	no	no	Training included self- and peer evaluation (error corrections).	no	meta-cognitive
35	Pickl, 2004	40	RES (6), MOT (2)	26.4	no	Participants received individual feedback regarding strategy application.	no	weekly [c] standardized questionnaires	social-cognitive
36	Rezvan et al., 2006	60	PF (1)	20.6	yes	no	Students gave and received peer feedback.	no	meta-cognitive

Table 3 *(continued)*

No.	Authors	*N*	Outcome (# ES)	Age	Under-achiever	Feedback	Cooperative Learning	Learning Protocols	Background/ Training Emphases
37	Richards & Perry, 1978	36	PF (1)	NA	no	no	no	no	cognitive/ resource strategies
38a	Rosário et al, 2010		META (1)	20.0	no	no	Each session, groups exchanged ideas and solved typical SRL problems for	no	social-cognitive

							45 minutes.		
38b				20.4					
39a	Rosário et al, 2015	117	META (1) MOT (1)	18.7	no	no	Each session, groups exchanged ideas and solved typical SRL problems for 45 minutes.	no	social-cognitive
39b		108		20.0					
39c	Rosário et al, 2015 (3)	151		18.6					

Table 3 *(continued)*

No.	Authors	*N*	Outcome (# ES)	Age	Under-achiever	Feedback	Cooperative Learning	Learning Protocols	Background/ Training Emphases
39d	Rosário et al, 2015 (4)	144		18.7					
40	Schmitz, 2001	60	COG (1), META (3), RES (7), MOT (1)	21.4	no	no	no	daily [c] standardized pre- & post-learning questionnaires	social-cognitive
41	Schmitz & Wiese, 2006	40	META (1), RES (7), MOT (3)	23.5	no	no	no	daily [c] standardized pre- & post-learning questionnaires	social-cognitive
42	Seel, 1984	50	COG (1) RES (2) MOT (1)	NA	no	no	no	no	cognitive/ resource strategies

Table 3 *(continued)*

No.	Authors	*N*	Outcome (# ES)	Age	Under-achiever	Feedback	Cooperative Learning	Learning Protocols	Background/ Training Emphases
43	Shen & Liu, 2011	53	META (4)	NA	no	no	no	no	meta-cognitive

Table 3 *(continued)*

No.	Authors	*N*	Outcome (# ES)	Age	Under-achiever	Feedback	Cooperative Learning	Learning Protocols	Theoretical Background
44	Sugitani, 2020	59	MOT (1)	NA	no	no	no	no	social-cognitive
45	Thompson, 2007	45	COG (4), META (1), RES (2), MOT (5)	NA	yes	no	Group problem solving; Groups discussed (dis-) advantages of learning strategies.	no	meta-cognitive
46	Tuckman, 2003	794	PF (1)	NA	yes	no	no	no	social-cognitive
47	Wagner et al., 2010	168	PF (2), COG (2), META (3), RES (2), MOT (3)	24.0	no	no	no	no	social-cognitive
48	Wallin, 2016	65	PF (1)	NA	yes	no	no	weekly [c] standardized questionnaires	social-cognitive
49	Wernersbach et al., 2014	237	COG (2), META (2), RES (3), MOT (3)	21.2	yes	no	no	no	cognitive/ resource strategies

Note. # ES = number of effect sizes, PF = academic performance, COG = cognitive strategies, META = metacognitive strategies, RES = resource management strategies, MOT = motivational outcomes. NA = Information not available.
Background/ Training Emphases: Cognitive/ resource strategies = Training programs focused on cognitive strategies and resource strategies, e.g. study skill courses or learning-to-learn courses (e.g., Weinstein & Mayer, 1985). Metacognitive = Training programs based on metacognitive theories (e.g., Flavell, 1979) that focused on teaching metacognitive strategies. Social-cognitive = Training programs based on social-cognitive theories (e.g, Zimmerman, 2002) that emphasized motivational aspects and resource management strategies.
o learning diary with open format that mainly included open-ended questions and reflection questions.
c learning diary with closed format, i.e., including mainly closed Likert scales and structured questions.

Data Screening and Assessment of Publication Bias

Publication bias was examined for each outcome category using five separate funnel plots (see Figure 2). Effect sizes were plotted in relation to the expected mean value for each outcome category with outliers outside the contour lines. Further, the trim and fill method was applied to compare the obtained distribution of effect sizes to the predicted distribution of effect sizes (Duval & Tweedie, 2000).

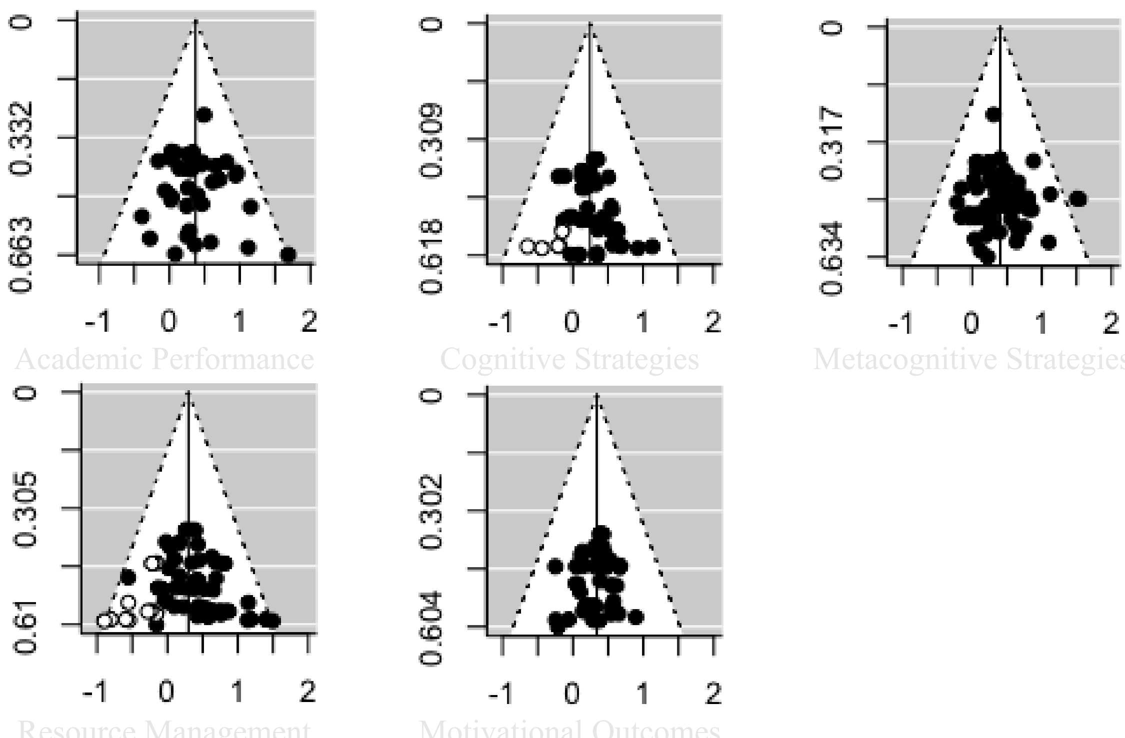

Figure 2. Funnel plots for each outcome variable. Effect sizes (Hedge's *g*, x-axis) are plotted against the standard error (y-axis). The vertical reference lines represent the mean Hedge's *g* within each outcome category. Black dots indicate original data. White dots represent imputed values that were added by the trim-and-fill procedure.

The Egger's regression test for funnel plot asymmetry was not significant for academic performance (z = .39, p = .697), cognitive strategies (z = 1.32, p = .188), metacognitive strategies (z = .49, p = .621), and motivational outcomes (z = -.29, p = .770). Hence, these results point to a symmetric distribution of effect sizes around the mean effect for these outcome categories.

However, the Egger's regression test was significant for resource management strategies (z = 2.00, p = .046) indicating funnel plot asymmetry. The funnel plot shows that some small to negative effect sizes were missing on the left-hand side of the plot which were imputed by the trim-and-fill procedure (the white dots).

Publication bias was tested by comparing average effect sizes reported in peer-reviewed studies with average effect sizes reported in unpublished studies (i.e., dissertations) (Rosenthal, 1979). Publication bias was detected for academic achievement. That is, published studies reported higher effect sizes than unpublished studies (b = .34, p = .023). No publication bias was detected for the remaining outcome measures.

Training Effects by Outcome Measure

The overall combined average effect size based on 251 effect sizes was .38 ([.32, .44], z = 11.98, p < .001). The largest average effect sizes were obtained for metacognitive strategies (g = .40, [.31, .49], z = 8.74, p < .001) and resource management strategies (g = .39, [.26, .51], z = 5.97, p < .001) followed by academic performance (g = .37, [.25, .49], z = 6.09, p < .001), motivational outcomes (g = .35, [.28, .41], z = 10.75, p < .001), and cognitive strategies (g = .32, [.21, .42], z = 5.80, p < .001). The average effect sizes did not differ significantly between outcome categories. Average effects for each subcategory are provided in Figure 3.

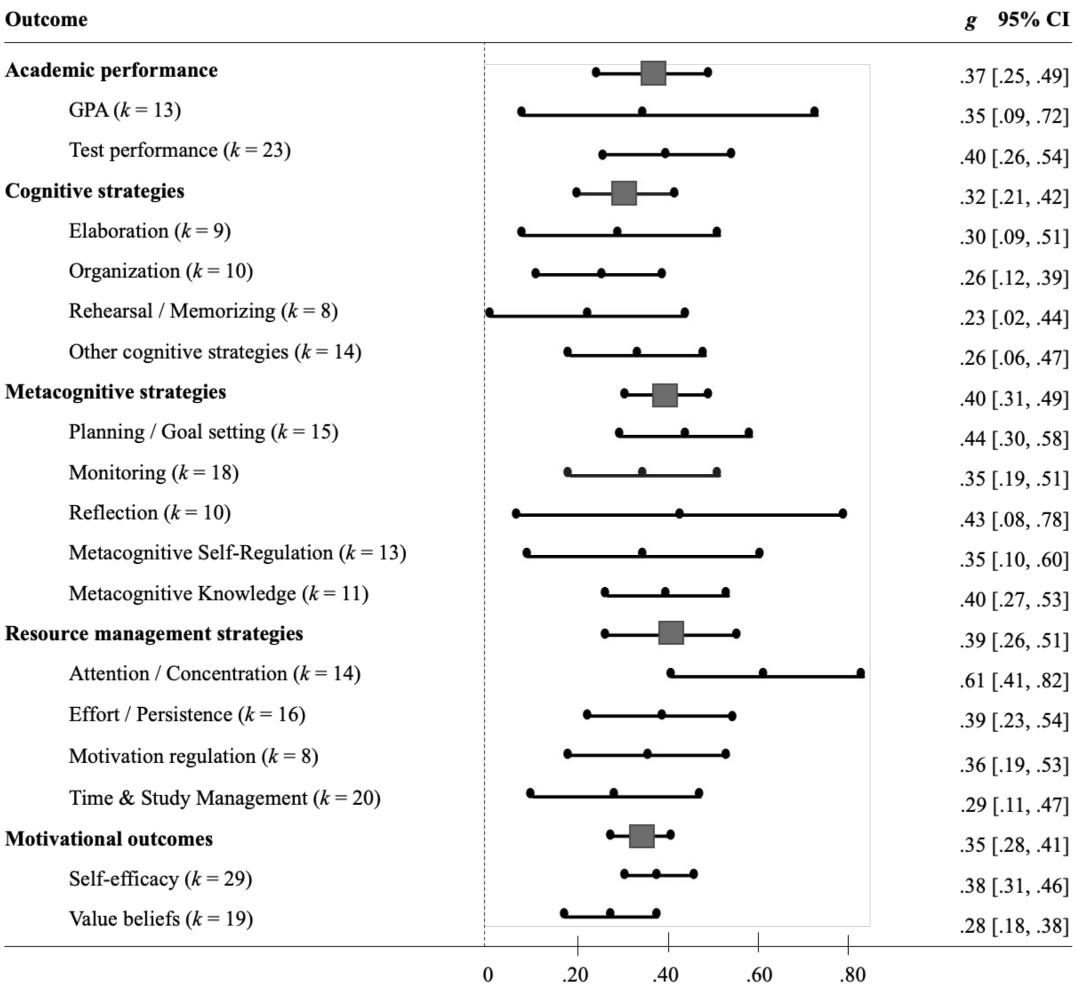

Figure 3. Average effect sizes for higher-level and lower-level outcome measures. Average effect sizes for the five higher-level outcome measures are highlighted with rectangles (academic performance, cognitive strategies, metacognitive strategies, resource management strategies, and motivational outcomes).

Next, it was analyzed whether the average effects differed significantly between subcategories within a particular higher-level category. Although average effect sizes differed in absolute size, those differences were not significant.

Moderator Analyses

Substantial heterogeneity in effect sizes was detected ($Q(250) = 498.705$, $p < .001$, Total $I^2 = 54.59$), which justified moderator analyses. Moderator analyses were conducted for each outcome category separately. All moderator variables (training design characteristics and student characteristics) were tested together for significance to control for shared variance among the moderator variables (Card, 2012).

Table 4

Results of the Moderator Analyses

Moderator	Academic Performance ($n = 19$, $k = 22$)		Cognitive Strategies ($n = 16$, $k = 32$)		Metacognitive Strategies ($n = 26$, $k = 61$)		Resource Management ($n = 18$, $k = 51$)		Motivational Outcomes ($n = 17$, $k = 37$)	
	Est. [CI]	*p*	Est. [CI]	*p*	Est. [CI]	*p*	Est. [CI]	*p*	Est. [CI]	*p*
Feedback	.071 [-.340; .482]	.824	-.031 [-.258; .196]	.789	.337 [.089; .585]	.005	.261 [.095; .427]	.002	.320 [.005; .635]	.046
Cooperative Learning	-.002 [-.357; .353]	.903	.265 [.025; .504]	.031	.240 [.056; .424]	.011	-.087 [-.254; .081]	.310	-.084 [-.251; .082]	.319
Learning Protocols	< .001 [-.397; .397]	.435	.170 [-.050; .389]	.129	-.012 [-.201; .178]	.905	.362 [.178; .545]	< .001	-.069 [-.244; .105]	.436
Age	-.056 [-.150; .038]	.128	.031 [.001; .061]	.045	-.012 [-.028; .055]	.524	.044 [.009; .078]	.013	-.027 [-.057; .004]	.084
Prior Achievement	.035 [-.358; .429]	.395	.072 [-.164; .308]	.549	.185 [-.145; .515]	.272	.279 [.073; .485]	.008	-.022 [-.226; .182]	.834

Note. Coefficients are unstandardized. Prior achievement was dummy coded (1 = training program targeted underachieving students, 0 = training program targeted regular students).

Academic performance. Training effects on academic performance were not moderated by training design or student characteristics. Therefore, a follow-up analysis was conducted to test whether training content moderated training effects on academic achievement. All training programs encompassed the instruction of multiple SRL strategies. Hence, it was not possible to test the effectiveness of specific SRL strategies. However, trainings differed in their relative focus on groups of SRL strategies based on their theoretical background. Study skill trainings were based on cognitive learning theories and focused on cognitive and resource management strategies (cf. Weinstein & Mayer, 1985). Metacognitive trainings were based on metacognitive theories (e.g., Flavell, 1979) and focused on metacognitive strategy instruction, e.g., planning, monitoring, and evaluation. Social-cognitive trainings were based on social-cognitive theories (e.g., Zimmerman, 2002) and typically focused on the instruction of resource management strategies and metacognitive strategies.

Results revealed that training effects on academic achievement differed depending on the theoretical background of the training. Training programs based on metacognitive theories ($g = .63$, CI [.33; .93]) reported the largest effects for academic achievement followed by trainings based on social-cognitive theories ($g = .38$, CI [.15; .61]) and study skill trainings that focused on cognitive and resource management strategies ($g = .28$, CI [.13; .42]). Post-hoc contrast analyses further revealed that metacognitive trainings showed significantly higher training effects compared to study skill trainings ($z = 2.23$, $p = .026$), but not compared to social-cognitive trainings ($z = 1.76$, $p = .077$). Taken together, results suggest that training programs based on metacognitive theories improve students' academic performance more than study skill trainings based on cognitive theories.

Cognitive, metacognitive, and resource management strategies. The moderator analyses for cognitive, metacognitive, and resource management strategies included a dummy variable that indicated whether the training program targeted the respective outcome category. For instance, the moderator analysis for cognitive strategies included a dummy variable indicating cognitive strategy instruction. Hence, it was tested whether training design moderated training effects on cognitive strategy use over and above the instruction of cognitive strategies. Equivalent dummy variables were included in the moderator analyses for metacognitive strategies and resource management strategies, respectively. Studies that tested the effects of training programs for cognitive, metacognitive, or resource management strategies typically included the instruction of the respective strategies. Therefore, the dummy variables did not add to the prediction of the average training effects.

Results revealed several moderating effects (see Table 4). Feedback predicted larger training effects for metacognitive strategies and resource management strategies. Cooperative learning predicted higher training effects for cognitive and metacognitive strategy use. The provision of learning protocols predicted larger training effects for resource management strategies. Further, older students and underachieving students benefitted more regarding their resource management strategies. The relation between students' age and cognitive strategy use was not significant anymore after applying Bonferroni-Holm correction.

Next, it was explored whether the moderating effects of training design and student characteristics varied for the subcategories of cognitive, metacognitive, and resource management strategies (see Table 5). This analysis served to detect potential differences in moderator effects within each outcome category. Note that some combinations of moderator and outcome variables could not be tested because the moderator variable was not assessed for this outcome variable. Further note that some of the tests were based on a small number of primary studies and effect sizes.

Table 5

Results of the Moderator Analyses for Subcategories

	Moderator variables														
	Feedback			Cooperative Learning			Learning Protocols			Age			Prior Achievement		
Outcome variable	# *N* (# *k*)	Est. [CI]	*p*	# *N* (# *k*)	Est. [CI]	*p*	# *N* (# *k*)	Est. [CI]	*p*	# *N* (# *k*)	Est. [CI]	*p*	# *N* (# *k*)	Est. [CI]	*p*
Cognitive Strategies															
Elabo-ration	2 (2)	-.221 [-.756; .313	.417	5 (6)	-.407 [-1.55; .740]	.487	5 (6)	.686 [-.395; 1.77]	.213	6 (6)	.012 [-.063; .087]	.324	1 (1)	.397 [-.273; 1.07]	.245
Organi-zation	2 (2)	.136 [-.301; .573]	.612	2 (2)	.314 [-.473; 1.10]	.435	3 (3)	.426 [-.035; .888]	.070	9 (9)	.035 [-.021; .599]	.091	3 (3)	.199 [-.201; .599]	.330
Rehearsal	2 (2)	-.081 [-.638; .477]	.472	2 (3)	-.061 [-.451; .328]	.757	3 (4)	.172 [-.248; .591]	.426	5 (5)	.037 [-.023; .098]	.228	1 (1)	.389 [-.336; 1.12]	.293
Other	4 (4)	-.107 [-.501; .286]	.593	4 (6)	.457 [.047; .867]	.029	4 (4)	.005 [-.435; .445]	.982	10 (12)	.057 [-.006; .120]	.078	3 (3)	.022 [-.380; .435]	.914
Metacognitive Strategies															
Goal/ Planning	3 (3)	.166 [-.269; .601]	.455	6 (10)	.370 [.108; .632]	.006	7 (10)	-.032 [-.328; .264]	.832	10 (14)	-.036 [-.135; .063]	.471	NA		
Monitoring	2 (2)	-.309 [-.807; .188]	.223	4 (4)	.503 [.154; .853]	.005	7 (7)	.194 [-.144; .532]	.260	13 (17)	.043 [-.042; .129]	.322	2 (4)	.322 [.011; .634]	.043
Reflection	1 (2)	1.17 [.697; 1.64]	< .001	4 (5)	.091 [-.249; .431]	.600	5 (7)	-.418 [-.835;-.022]	.049	7 (9)	-.005 [-.110; .099]	.923	NA		
Regulation	4 (6)	.174 [-.253; .602]	.424	3 (3)	.395 [-.049; .838]	.081	5 (7)	-.030 [-.427; .412]	.893	8 (10)	.070 [-.004; .145]	.065	1 (1)	.033 [-.564; .631]	.913
Know-ledge	NA			9 (10)	.883 [-.698; 2.46]	.274	3 (3)	-.233 [-.638; .172]	.259	10 (11)	.068 [-.075; .211]	.353	NA		

Resource Management Strategies															
Attention	4 (6)	.337 [.056; .617]	.019	3 (3)	-.117 [-.476; .243]	.525	4 (6)	.199 [-.092; .148]	.180	8 (13)	.123 [.054; .192]	< .001	1 (1)	-.324 [-.773; .125]	.158
Effort	3 (4)	.364 [.019; .710]	.039	6 (6)	.024 [-.313; .361]	.140	8 (10)	.150 [-.155; .455]	.337	12 (14)	.071 [.003; .139]	.042	2 (2)	-.075 [-.387; .237]	.636
Motivation Regulation	2 (2)	.675 [-.864; 2.21]	.390	2 (4)	-.061 [-.966; .844]	.859	5 (7)	1.02 [-1.04; 3.08]	.333	6 (8)	-.065 [-.397; .268]	.703	NA		
Time Man-agement	3 (5)	.522 [.155; .888]	.005	6 (8)	-.392 [-.775;-.009]	.045	9 (13)	.557 [.207; .907]	.002	12 (16)	.047 [-.007; .101]	.091	4 (4)	.449 [.023; .874]	.039

Note. Coefficients are unstandardized. # *N* = number of primary studies and # *k* = number of effect sizes used to calculate average effect. NA = moderator variable not assessed for this outcome variable. Prior achievement was dummy coded (1 = training program targeted underachieving students, 0 = training program targeted regular students).

After applying Bonferroni-Holm correction several moderator effects were found. Cooperative learning significantly moderated the training effects for the combined cognitive strategy measure that subsumed several strategies, but not for elaboration, organization, nor rehearsal. Cooperative learning further predicted higher training effects for planning and goal setting as well as monitoring, but not for the remaining subcategories of metacognitive strategies. Feedback moderated training effects for metacognitive reflection but not for the remaining subcategories of metacognitive strategy use. Feedback further moderated training effects for attention and concentration, effort, and time management but not for motivation regulation strategies. Leaning protocols moderated training effects for time management but not for the remaining resource management strategies. Moreover, students' age was related to training effects for attention and concentration. That is, older students especially improved their attention and concentration. Although prior academic achievement moderated training effects for resource management strategies, there was no moderator effect for the subcategories. One explanation is that the number of effect sizes for the subcategories was too low, which limited statistical power.

Motivation. Results revealed that feedback predicted training effects for motivational outcomes (see Table 4). That is, training programs that included teacher feedback reported higher effect sizes for motivational outcomes. The remaining moderator variables did not predict training effects.

Discussion

The present meta-analysis tested the effectiveness of SRL training programs for university students. Results revealed small to medium average effects for academic performance (g = .37), cognitive strategies (g = .32), metacognitive strategies (g = .40), resource management strategies (g = .39), and motivational outcomes (g = .35) (Cohen, 1992). Training effects varied for specific SRL strategies and ranged from .23 (e.g., rehearsal) to .61. (e.g., attention and concentration). Together, these results indicate that SRL training programs can effectively enhance university students' academic performance, SRL strategies, and motivation. Further, moderator analyses revealed that training design, theoretical background of the training program, and student characteristics moderated training effects. Below, results are discussed separately for each outcome category.

Do SRL Training Programs Increase Students' Academic Performance?

Results supported previous meta-analytical findings that revealed positive effects of SRL training programs on academic performance. The average effect size was, however, smaller compared to the average effects obtained for primary and secondary school children (Dignath & Büttner, 2008; Donker et al., 2014). One explanation is that university students constitute a selective, high-achieving group which makes it more difficult to raise their academic performance further (Hattie et al., 1996). However, despite this selectivity, SRL training programs effectively enhanced students' academic performance – even irrespective of students' age or prior academic performance.

The average effect size was comparably lower if academic performance was operationalized as GPA (instead of test performance), which is in line with previous findings (Jansen et al., 2019). It might take more time to improve students' GPA because GPA subsumes a multitude of academic performance measures from various exams assessed over a longer period of time. Hence, longitudinal studies including follow-up surveys are needed to test long-term effects of SRL training programs on students' GPA.

Results further revealed that training effectiveness differed depending on the theoretical background of the training. Training programs were more effective if they were based on metacognitive theories compared to study skill trainings that were based on cognitive theories. This finding is in line with previous findings from Dignath and Büttner (2008) who also found that metacognitive trainings especially improved academic performance.

Which training characteristics make metacognitive trainings more effective? A closer inspection of the training programs offers a potential explanation: Almost all metacognitive trainings (7 out of 9, 78%) included at least one instructional tool to enhance metacognitive reflection, i.e., feedback, cooperative learning arrangement, and/or learning protocols (see Table 3) while this was rarely the case for study skill trainings (4 out of 20; 20%). For instance, some study skill trainings also covered a few metacognitive strategies related to a particular task, such as setting goals for an exam. However, students were not trained to reflect on the usefulness of the strategies or how to adapt the strategy for a different task. This result suggests that the instruction of metacognitive strategies is especially effective if students further learn how, when, and why to apply those strategies. An exploratory follow-up analysis revealed that training programs that included at least one method to enhance metacognitive reflection (feedback, cooperative learning arrangements, or learning protocols) improved students' academic performance more than training programs that did not include any of those methods (b = .29, CI [.064, .511], p = .012). This result suggests that metacognitive reflection benefits training effectiveness. At the same time, it seems to be less important how metacognitive reflection is promoted, e.g., through feedback, cooperative learning arrangement, or learning protocols.

Another difference between metacognitive trainings and study skill trainings is that metacognitive trainings were frequently integrated in a specific, content-related university course, e.g., a language learning course or math tutorial. Six out of nine metacognitive trainings (66%) were integrated in a course on a specific topic while this was the case for only 40% of the study skill trainings (8 out of 20). Integrated training programs teach learning strategies related to a specific learning content. Integrated training programs may help students to understand how, when, and why they should use a specific strategy (Hattie et al., 1996), thereby reducing production deficits in strategy application (Veenman et al., 2006).

To conclude, results of this meta-analysis show that SRL training programs can effectively enhance university students' academic performance. Second, results of the moderator analyses point to the conclusion that SRL training programs are more effective if they include methods to encourage metacognitive reflection, i.e., if they encourage students to reflect how, when, and why they should apply SRL strategies.

Do SRL Training Programs Enhance SRL Strategy Use?

Findings from this meta-analysis support results from previous meta-analyses that showed positive effects of SRL training programs on SRL strategy use (Hattie et al., 1996; Jansen et al., 2019). This meta-analysis added to previous research by showing that training effects differed for specific SRL strategies.

Training effects for cognitive strategies were comparably smaller than training effects for metacognitive and resource management strategies. One explanation is that older students may have already acquired a strategy repertoire that gets more difficult to change with age (Dignath, Buettner, & Langfeldt, 2008). This would further explain why previous meta-analyses that focused on primary and lower secondary school children found higher average effect sizes (Dignath & Büttner, 2008; Hattie et al., 1996). Another explanation is that it takes more extensive training to further improve university students' cognitive strategies. For instance, social-cognitive trainings often covered cognitive strategies but the instruction of cognitive strategies was not the main focus of the trainings. Therefore, the instruction and training of cognitive strategies was rather brief compared to the instruction of metacognitive and resource management strategies. As an example, several training programs (Bellhäuser et al., 2016; Dörrenbächer et al., 2016; Rosário et al., 2010, 2015) encompassed six training sessions and only one out of six sessions covered cognitive strategy use. Hence, future studies should test whether university students would benefit from more extensive training of cognitive strategies.

Training programs further improved students' metacognitive and resource management strategies but the average effects differed among strategies. Students strongly improved their goal setting and planning strategies as well as their monitoring strategies. That is, students reported to set goals and make plans (before learning), and to monitor and reflect on current progress towards their goals and plans (during and after learning). However, self-regulating study behavior (after learning) seems to be more difficult for students. A similar picture emerged for resource management strategies. Training effects regarding the regulation of motivation, time, and study environment were comparably lower than training effects for self-reported attention or effort. Hence, monitoring current attention or effort might be easier than applying strategies to effectively regulate these processes. Together, these results point to a gap between planning and monitoring on the one hand, and the effective self-regulation of learning strategies and resources on the other. The effective self-regulation of learning strategies and resources is especially important for academic success (Broadbent & Poon, 2015; Richardson et al., 2012). Hence, more research is needed to find out how students' self-regulation strategies can be promoted most effectively (see chapter below).

Taken together, SRL training programs improved students' metacognitive strategies, resource management strategies, and – to a smaller degree – students' cognitive strategies. This meta-analysis provided first evidence on the effects of SRL training programs on various SRL strategies. The smallest average effect size was obtained for rehearsal strategies. Notably, however, rehearsal strategies such as summarizing or rereading are not very useful to improve students' learning (Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013). In contrast, SRL training programs especially improved planning and goal setting, monitoring, and resource management. These strategies have been shown to be central for university students' academic performance (Broadbent & Poon, 2015; Dent & Koenka, 2016; Richardson et al., 2012). Hence, SRL training programs fostered strategies that benefit students' academic success.

Which training design characteristics predict SRL training effectiveness? Results revealed that training design characteristics moderated the effects of SRL training programs on SRL strategies. First, moderator analyses revealed that training programs that included cooperative learning arrangement reported larger average effects for cognitive and metacognitive strategies. Cooperative learning arrangements offer students the opportunity to share responsibilities, ideas, and thoughts. For instance, students discuss the effectiveness of specific cognitive and metacognitive strategies (e.g., Rosário et al., 2015, see Table 3). Further, peer feedback is frequently mentioned as an important element in cooperative learning (e.g., Bail et al., 2008). Feedback and group discussions stimulate metacognitive monitoring and reflection on goals and plans. Reflecting on the appropriate use of specific strategies might, in turn, encourage students to apply those strategies in daily life.

Teacher feedback was associated with higher training effects for metacognitive strategies (especially metacognitive reflection) and various resource management strategies. Teacher feedback frequently comprises self-regulation feedback, i.e., feedback on the appropriate use of SRL strategies (e.g., Eide, 1999, see Table 3). This type of feedback does not only inform students about their current use of learning strategies (*feed back*) but also includes concrete hints on how to improve learning strategies (*feed forward*; see Hattie & Timperley, 2007). That is, feedback helps students to reflect on their current SRL activity and facilitates the selection and regulation of learning strategies. Feedback thus plays an important role for self-regulated learning by supporting students' self-reflection and regulation.

Moreover, training programs that included learning protocols reported higher effect sizes for students' resource management strategies. Notably, a follow-up analysis revealed that learning protocols especially benefitted students' time management. Hence, learning protocols may help student to keep track of their time investment and to manage their time more effectively. Following this interpretation, it may be surprising that learning protocols did not improve students' metacognitive strategy use. One explanation is that learning protocols do not improve all aspects of metacognitive strategy use to the same degree. Descriptively, learning protocols were positively related to monitoring, but negatively related to the remaining metacognitive strategies (see Table 5). This finding highlights that training effects and also moderators of training effects should be considered specifically for different SRL strategies. Taken together, results suggest that learning protocols can improve students monitoring and regulation of their study time.

In summary, moderator analyses revealed that training design characteristics predicted differences in training effectiveness. These moderator variables share a common feature: They all aim to improve metacognitive reflection among students. Teacher or peer feedback, group discussions, and learning protocols likely stimulate reflection about how, when, and why to apply a certain strategy. Metacognitive reflection can help students to overcome production deficits that originate from a lack of knowledge on the efficient use of SRL strategies (Veenman et al., 2006). In sum, these results suggest that activities that promote metacognitive reflection enhance training effectiveness.

Do SRL Training Programs Improve Students' Motivation?

SRL training programs improved university students' motivation. After training, students reported more intrinsic motivation and interest. What is more, students improved their self-efficacy. This is an important finding given that self-efficacy is strongly related to university students' academic success (Richardson et al., 2012; Schneider & Preckel, 2017). Further, students' motivation plays an important role in SRL (Schunk & DiBenedetto, 2020; Zimmerman, 2000, 2002) and guides students' choice of learning strategies (Liem et al., 2008; Pintrich, 1999). Hence, SRL training programs can effectively improve an important aspect of students' learning.

Results of the moderator analysis further revealed that teacher feedback improved training effects for motivational outcomes. Teacher feedback constitutes one source of self-efficacy (Bandura, 1997): Teachers can convince students that they possess the capabilities to master a certain activity or can help students notice their success. This increased feeling of competence may also raise students' interest and subjective value of the task (see e.g., Pekrun, 2006). Taken together, teacher feedback can be viewed as one way to enhance SRL training effects on students' motivation.

In sum, this meta-analysis provided first evidence on the positive effects of SRL training programs on students' control and value beliefs. Teacher feedback can even increase those positive effects, which is in line with theoretical models on the origins of self-efficacy.

Who Benefits from SRL Training Programs?

SRL training programs improved university students' academic performance, cognitive and metacognitive strategies, and motivation irrespective of their age or prior academic achievement. However, individual differences in university students' age and prior academic achievement moderated training effects for resource management strategies. Older students and underachieving students benefitted more regarding their resource management strategies. Although speculative, older students and underachieving students might have struggled more with their resource regulation before starting the training and thus had more room for improvement. In line with this hypothesis, it was , for instance shown that underachievers frequently report difficulties in time and study management (Balduf, 2009). Taken together, moderator analyses revealed only few differential effects suggesting that most students can potentially benefit from SRL training programs.

Avenues for Further Research on SRL Training Programs

Assessing SRL training effects. The present meta-analysis revealed a predominant use of retrospective self-reports to assess SRL strategy use. On the one hand, retrospective self-reports have several strengths: They provide important insights on students' perception of their SRL, which guides their study decisions (McCardle & Hadwin, 2015). Self-report questionnaires are also useful to assess and to differentiate between different aspects of motivation (Fulmer & Frijters, 2009), e.g., value and control beliefs. Further, self-report questionnaires predict individual differences in students' academic achievement (e.g., Richardson et al., 2012), which speaks for their predictive validity. On the other hand, retrospective self-reports may be incomplete or inaccurate due to memory biases (Rovers, Clarebout, Savelberg, de Bruin, & van Merriënboer, 2019). Hence, alternative ways to assess SRL processes are needed to evaluate training effects (see Veenman, 2011 for an overview). A review of the studies included in this meta-analysis revealed four avenues for further research.

First, a repeated assessment of SRL strategies, e.g., using ambulatory assessment or learning protocols, constitutes one way to reduce memory biases of retrospective self-reports (for an overview see Klug et al., 2011; Panadero et al., 2016). Although these repeated assessments are still based on self-reports, learning strategies are assessed more frequently and with regard to a specific learning situation. For instance, a recent study demonstrated the predictive value of daily self-reports over retrospective self-reports (Breitwieser et al., *in press*). The authors showed that daily reported volitional control predicted daily goal achievement over and above retrospectively reported volitional control. Several studies included in the current meta-analysis used learning protocols to assess students' daily application of learning strategies before and after learning (see e.g., Bellhäuser et al., 2016; Broadbent et al., 2020). However, these studies did not compare the daily development of SRL strategies to the development in a control group without training. Hence, future studies could evaluate training effects by comparing the development of daily SRL in a training and control group.

Second, behavioral measures, such as log-files, could provide a more accurate measure of students' actual study behavior in a given situation. Only three studies included in this meta-analysis used log-file measures to assess students' learning strategies (Bernacki, Vosicka, & Utz, 2020; Bernacki, Vosicka, Utz, et al., 2020; Cogliano et al., 2020). For instance, they assessed how often students accessed planning resources on a web-based learning platform (planning), or how often students tested their knowledge (monitoring). However, to date, the number of studies that used log-files to assess SRL is too small to draw conclusions about differences in effect sizes gained from self-report and log-file data. Future studies should extend this promising line of research. Studies could combine log-files and self-report measures of SRL to evaluate training effects and to compare their predictive value.

Third, SRL knowledge tests could be used to assess students declarative or conditional knowledge of SRL strategies. Six studies included in this meta-analysis used SRL knowledge tests to evaluate training effectiveness (Bellhäuser, 2016; Bellhäuser et al., 2016; Biwer et al., 2020; Broadbent, Panadero, & Fuller-Tyszkiewicz, 2020; Rosário et al., 2010, 2015). These tests assessed students' knowledge about SRL strategies and models (see Broadbent et al. 2020), or knowledge about the effectiveness of specific SRL strategies (see Biwer et al., 2020). Knowledge tests could further serve as a measure of training fidelity. For instance, students who were in the training group but perform poorly in the knowledge test may have not paid attention to the instruction, or failed to attend all training sessions. Thus, knowledge tests could not only be used to evaluate training effects (in comparison to a control group) but also serve as a measure of training fidelity within the training group.

A final aspect concerns the assessment of long-term effects of training programs. For instance, some training effects might be observed with delay as changing one's study habits takes some practice. Similarly, training effects on academic outcomes could increase over time as students become more experienced in applying the new strategies. On the other hand, a recent review revealed that training effects often fade out over time (Bailey, Duncan, Cunha, Foorman, & Yeager, 2020). Hence, longitudinal studies should be conducted to reveal potential long-term effects of attending SRL training programs and to test the persistence of those effects.

Design and target group of SRL training programs. The moderator analyses and the review of SRL training programs revealed four promising directions for further research. First, more research is needed to find out why some training programs are more effective than others. However, information on training design characteristics was often limited. For instance, many studies did not report training duration nor how long a specific strategy had been trained.

Therefore, it was not possible to test training intensity as a moderator of training effectiveness. One hypothesis is that training effects for specific strategies increase with training intensity. Hence, to facilitate moderator analyses, future studies should share detailed descriptions of the SRL training programs including schedules and materials.

Secondly, more systematic experimental research is needed to find out when feedback, cooperative learning arrangements, and learning protocols promote SRL strategies, academic performance, and motivation. Moderator analyses revealed that moderator effects varied for specific outcomes and even within an outcome category. Future research could, thus, investigate which SRL outcomes especially benefit from feedback, cooperative learning, and learning protocols. These studies could further examine why these training design characteristics benefit training effects, e.g., by testing metacognitive reflection as a potential mechanism.

Thirdly, it is still largely unclear who particularly benefits from SRL training programs. The present meta-analysis focused on age and prior academic achievement. However, studies only reported average age and achievement level for the whole training group. This aggregation neglected individual differences within the training sample. Further, this meta-analysis focused on university students, which limits the variance in age and achievement level. Moreover, other student characteristics could moderate training effects. For instance, one study revealed that training effects depended on students' SRL skills and motivation at the beginning of the training (Dörrenbächer & Perels, 2016b). Students with low initial SRL skills and high motivation as well as students with moderate SRL skills benefitted from training, while students with high SRL skills did not. That is, students who already apply effective SRL strategies probably do not need further support. From a practical point of view, this is an important point because SRL training programs are time- and cost-intensive and should only be provided to students who don't know appropriate learning strategies. Considering students' prior knowledge and strategies would further open up the possibility to individualize instruction based on students' needs. However, to date, research on differential training effects is scarce. Therefore, future research should investigate differential training effects (1) to identify students who especially benefit from SRL training programs and (2) to develop training programs that fit students' individual needs.

Fourth, future research should develop adaptive training approaches that consider intra-individual differences in SRL. For instance, studies that used intensive longitudinal data to assess the dynamics of SRL revealed substantial variability in SRL strategy use over time (Liborius et al., 2019; Theobald, Breitwieser, Murayama, & Brod, 2021). These findings underline that SRL constitutes a dynamic process that can vary from one day to the next. This dynamic view of SRL calls for adaptive training approaches. That is, SRL strategies should be assessed repeatedly over the course of the training to personalize the instruction (see Tetzlaff et al., 2020 for a general framework for dynamic, personalized education). For instance, learning protocols could be combined with adaptive self-regulation prompts. If students report low levels of motivation before learning, they could receive strategy suggestions to enhance their motivation. Taken together, future training programs should develop situation-specific and adaptive ways of promoting SRL in daily life.

Practical Implications

Results of the present meta-analysis provide several practical implications. First, to increase students' academic achievement, training programs should focus on metacognitive strategies and reflection. Results of the moderator analyses revealed that metacognitive trainings improved students' academic performance more than study skill trainings. Metacognitive trainings differed from study skill trainings in several regards. First, metacognitive trainings had a clear focus on the instruction of metacognitive strategies while study skill trainings focused more on the instruction of cognitive and resource management strategies. A majority of the metacognitive trainings included at least one tool to foster metacognitive reflection about how to use and adapt the newly acquired strategies - while this was rarely the case for study skill trainings. Hence, teachers should encourage students to reflect on the appropriate application of the instructed strategies and to adapt strategies for a specific learning content.

Moreover, metacognitive reflection should become an essential element in SRL training programs to improve SRL strategies. Rather than only increasing students' general strategy repertoire, teachers should foster students' knowledge on how, when, and why they should apply SRL strategies. For instance, feedback stimulated metacognitive reflection on learning outcomes, and improved students' self-regulation of time, effort, and concentration. Hence, feedback may be beneficial to students who have difficulties to keep track of their time and effort investment. Those students would further benefit from learning protocols, which have been shown to enhance training effects on time management. Furthermore, cooperative learning arrangements boosted training effects for goal setting and planning as well as monitoring. That is, students who struggle to set goals and to plan and monitor their goal progress could benefit from discussions and feedback from peers. Peer feedback and discussions could further help students to improve their cognitive strategies. Taken together, results of the moderator analyses suggest that feedback, cooperative learning arrangements, and learning protocols could be helpful tools to stimulate reflection and strategy regulation.

Teachers can use SRL training programs to improve students' motivation. In SRL training programs students learn how to become active learners and how they can take responsibility for their own learning processes. In this way, students have the opportunity to increase their self-efficacy and to develop intrinsic interest in a subject. To enhance training effects on motivation, teachers should offer students feedback about their SRL strategies. Ideally, teacher feedback should include concrete hints on how students can improve their strategies (Wisniewski et al., 2020). Doing so, teachers can convince students that they can master a certain activity, which promotes self-efficacy (Bandura, 1997).

Older students with lower prior academic achievement seemed to benefit more regarding their resource management strategies. Besides, moderator analyses did not yield differential training effects depending on age or prior achievement level. Put differently, results of the present meta-analysis did not reveal a clear target sample meaning that students at large are likely to benefit from participating in an SRL training program.

Conclusion

To conclude, SRL training programs enhanced academic performance, SRL strategies, and motivation of university students. The average training effects were comparable with average effect sizes obtained for educational interventions (Hattie, 2009) and for variables associated with academic performance in higher education (Schneider & Preckel, 2017). Training programs were conducted in real classrooms which supports the external validity of the findings. Given the importance of SRL for academic performance at universities, the demand for SRL training programs will not diminish. Future research should identify students who especially benefit from SRL training programs and develop adaptive training programs tailored to students' individual needs.

Open Practice Statement

The coding scheme, an overview of studies tested for eligibility, the data and the data analysis script are available via the Open Science Framework: https://osf.io/u6szn/.

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Note. References marked with an asterisk indicate studies included in this meta-analysis.

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