Exploring Long-Term Impacts of Self-Regulated Learning Interventions in K-12 Contexts: A Systematic Review

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Abstract: While research illustrates the benefits of interventions designed to improve self-regulated learning (SRL) and academic achievement, far fewer studies have examined the durability of these effects. This review synthesizes research on the lasting effects of 17 comprehensive SRL interventions on variables related to metacognition, cognition, motivation, and achievement in K-12 populations. Results reveal common patterns of design, domain-specificity, intervention complexity, and style of measurement instrument. Intervention effects tend to be durable regarding achievement and SRL but were mixed when presented across multiple measures of SRL. Overall findings imply that SRL interventions can lead to enduring effects on achievement and better achievement outcomes than content-strategy instruction alone and can be implemented successfully in a variety of contexts and subjects.

Introduction

Self-regulated learning (SRL) refers to the cyclical process wherein learners manage their own behaviors, emotions, and cognition before, during, and after a learning task (Panadero, 2017; Sitzmann & Ely, 2011). SRL is beneficial and related to students' academic performance in many contexts (Dorrenbacher & Perels, 2016; Panadero, 2017). Beyond formal academic environments, SRL is also valuable in ongoing personal and professional learning throughout one's life (Dignath et al., 2008; Sitzmann & Ely, 2011). Unfortunately, while SRL is clearly beneficial for learners, many individuals are not engaging in adequate self-regulation of learning and are unlikely to improve on their own; however, researchers have found that interventions can be helpful in improving learners' self-regulation (Dorrenbacher & Perels, 2016; Panadero, 2017; Richardson et al., 2012). SRL is a rich area of research, and over time many interventions have been studied in an attempt to support SRL in a variety of contexts and populations. Many

researchers have reported positive effects on students' academic achievement and SRL (Dignath & Buttner, 2008; Donker et al., 2014; Sitzmann & Ely, 2011). Given the relevance of SRL for learning throughout one's educational career and beyond, it is valuable to explore the lasting effects of such intervention over time. However, only a small portion of SRL intervention studies have included follow-up or maintenance data after the implementation period. Synthesizing these empirical studies affords important implications regarding the lasting effects of SRL interventions, practical applications for designers and instructors, and gaps in research.

Theoretical and Conceptual Framework

Several models and variations of SRL have emerged over time, but one of the most enduring and widely used models is Zimmerman's (2002) social cognitive model of SRL (Panadero, 2017). In fact, many of the studies included in this systematic review cite this model as the basis for their own theoretical frameworks. This model conceptualizes SRL as encompassing the metacognitive and cognitive processes that take place as a learner directs themselves through a learning task and cyclical feedback loop (Zimmerman, 2002). Zimmerman's (2002) model includes three phases: forethought, performance, and self-reflection. The first phase, forethought, occurs before learning and involves setting goals, planning what strategies to employ, assessing one's self-efficacy related to the task, and forming expectations about outcomes. It also includes the orientation of their learning goal (e.g., performance or mastery) as well as its intrinsic value (Zimmerman, 2002). The second phase takes place during learning and involves processes of self-control and self-observation. In this performance phase, learners employ cognitive strategies, self-instruction, attention focusing, and self-recording. The final stage of self-reflection includes self-evaluation, making causal attributions for performance, and reacting to the learning experience with emotions and adaptations. Other models of SRL have commonalities with Zimmerman's model and often include phases that capture learners' processes of preparing for, completing, and reflecting on a learning event. They further emphasize many of the same subprocesses and components, such as motivation, goal-setting, metacognition, strategy use, reactions, and adaptations (Panadero, 2017; Sitzmann & Ely, 2011).

SRL is associated with academic achievement, and this relationship has been supported by research in many subject areas and with a wide range of grade levels. SRL interventions have led to academic improvements in content areas such as reading, writing, science, and math at levels ranging from elementary through college populations (Dignath et al., 2008; Richardson et al., 2012). Some research has shown the particular importance of SRL at times when students are transitioning to a novel environment with greater expectations for autonomy as a learner, such as moving between levels of schooling (Dorrenbacher & Perels, 2016). Further, SRL is helpful for professional and personal learning beyond academic contexts and throughout an individual's life (Sitzmann & Ely, 2011).

Unfortunately, many students lack adequate self-regulation skills, which is detrimental to their learning and performance (Dignath et al., 2008; Zimmerman, 2002). Meta-analyses and reviews offer insight regarding the construction of effective SRL interventions (e.g., Dignath & Buttner, 2008; Donker et al., 2014). While students are unlikely to make spontaneous improvements to their self-regulation of learning, research reveals that students can see improvements in SRL as a result of training and intervention (Sitzmann & Ely, 2011). Such interventions have been successful even with elementary students for enhancing SRL and academic achievement (Sitzmann & Ely, 2011).

Although research on SRL interventions is encouraging and offers useful, practical implications for designing instruction, most of these studies only evaluate short-term effects assessed at an immediate posttest. Relatively few studies have included delayed follow-up measures. Given SRL's importance for learning at various stages, examining the durability of intervention effects is extremely valuable. When supporting SRL, educators should aim to bolster these skills so that students are able to continue engaging in these processes beyond the intervention period and contribute to ongoing academic success. However, there is a lack of comprehensive reviews and meta-analyses investigating these ongoing effects. One meta-analysis conducted by de Boer et al. (2018) explores the durability of metacognitive strategy interventions. However, while metacognitive strategies are a component of SRL, there are no systematic reviews or meta-analyses which examine the lasting effects of interventions targeting SRL more holistically and addressing multiple phases and subphases. Given the paucity of evidence, a review of studies which incorporate a comprehensive SRL intervention and assess its long-term effects is warranted in order to identify patterns for practical applications and gaps in the research literature.

Research Questions

This paper follows the guidance of Alexander (2020) in structuring a systematic review to address the following research questions:
1. What trends are present in SRL intervention studies that include follow-up measures?
2. Do SRL interventions have durable effects on students' achievement and self-regulated learning?

Method

In addition to Alexander's (2020) framework, guidance from Gough's work (2007) was utilized in developing the methodology. It involved defining inclusion and exclusion criteria, identifying sources of information and search terms, screening studies, extracting data, assessing methodological rigor of included studies, synthesizing the data, and interpreting overall findings.

Inclusion and Exclusion Criteria

In choosing appropriate inclusion and exclusion criteria, several factors were considered. First, the review was confined to studies within an academic context, rather than self-regulation that is behavioral, such as smoking cessation or weight-loss interventions. Further, since the relationship between SRL and achievement is critically relevant, the intervention should be designed based on self-regulated learning principles and intended to improve participants' SRL or their academic performance. Additionally, because of the strong academic benefits of SRL, this review is limited to interventions which approach SRL more comprehensively and address one or more components of all three phases. Hacker and Bol (2019) reported that more comprehensive SRL interventions were associated with more accurate metacognitive judgments and improved academic outcomes. In the present document, the interventions included are termed holistic. Because this review is specifically focused on long-term effects of SRL interventions, included studies must involve a delayed follow-up measure eight or more weeks following the intervention implementation period. Eight weeks was chosen as the lower limit to ensure that measured effects were lasting beyond just a few days or weeks after the intervention, targeting impacts that were, in fact, long term. Eight weeks is also a similar timeframe for

evaluations in response to intervention (RTI) programs as well as grading periods in K-12 school systems (Averill et al., 2014).

Finally, this review is limited to K-12 populations. The importance of SRL for K-12 students' academic achievement has been well demonstrated, and SRL interventions have been impactful for this population and within K-12 school settings (Dignath & Buttner, 2008; Panadero, 2017). It is also theorized that students may rely on SRL even more as they transition to more autonomous learning environments, such as college and many workplace settings (Bembenutty, 2011; Dorrenbacher & Perels, 2016). Therefore, early intervention may promote student development of effective SRL skills. The focus on K-12 is further warranted due to validity threats present in higher education samples. College student samples often require incentivization and may not reflect students in K-12 education, given barriers to entry of postsecondary education (Ferguson et al., 2004; Peterson, 2001). This review also excluded studies published in a language other than English as well as gray literature. There were no limiters associated with the year of publication. To summarize, the inclusion and exclusion criteria were as follows:

1. The context of the study is academic.
2. The study involves an intervention based on self-regulated learning principles aimed at improving students' SRL and/or academic achievement by way of SRL.
3. The SRL intervention is holistic, meaning that it targets subcomponents from each SRL phase of forethought, performance, and reflection, rather than focusing on a singular phase or subcomponent, or subcomponents from only two of the three phases.
4. The study includes a delayed posttest follow-up measure which takes place at least eight weeks after the intervention period.
5. The study sample consists of K-12 students.
6. The study is published in a peer-reviewed journal available in English.

Search Strategy

First, search terms were identified. The first search term was "self-regulated learning" or "self-regulation of learning." The word "learning" was included in these specific search phrases as the review is not focused on simply self-regulation of a specific behavior. Rather, this review specifically concerns self-regulation as it pertains to learning. While metacognition is at times used synonymously with SRL, it was not included since it is nested within the overall framework of SRL (Dinsmore et al., 2008). Because several concepts and processes are subsumed by SRL, searching for each of these individually would not have been feasible for the scope of this review. Further, interventions grounded in the SRL framework of SRL guided this review. Additional search terms included "follow up," "delayed follow up," "longitudinal," "lasting," "long term," "long-term," "maintenance," "intervention," and "treatment." These key terms were selected in order to retrieve studies which included a delayed posttest or follow-up measure, as well as experimental studies that included an intervention or treatment. Searches were conducted using the following databases: Education Source, APA PsycInfo, Education Research Complete, ERIC, Psychology and Behavioral Sciences Collection, Academic Search Complete, APA PsycArticles, and Google Scholar. With the exception of Google Scholar, all databases were searched simultaneously utilizing a platform, EBSCOhost, which automatically removes duplicates. This initial search resulted in a total of 170 results. The first ten pages of Google Scholar results were reviewed, adding another 100 search results ($n = 270$).

Study Selection

After searches were conducted, the resulting potentially relevant studies were initially screened using primarily abstracts and full texts as needed for clarification. At this point, studies were excluded if they did not include an SRL intervention, did not include delayed follow-up measures, were not in English, were not a peer-reviewed journal publication (such as a dissertation), or were purely aimed at behavior change or physical skill development rather than academic learning. Duplicate studies were also excluded at this time. Following this initial round of screening, a total of 35 studies were identified (22 from EBSCOhost searches, 13 from Google Scholar). An additional 11 studies were identified through reference tracking, bringing the total studies to 46. These remaining studies were retrieved in full for a more detailed screening against the identified inclusion and exclusion criteria.

Following this detailed evaluation against the above inclusion and exclusion criteria, 18 remaining studies were retained for coding and analysis. One study conducted by Fidalgo et al. (2008) is an additional delayed follow-up assessment to the earlier study published by Torrance et al. (2007), which also included its own shorter-term follow-up measures. Due to this occurrence, there are only 17 unique interventions within the 18 identified articles. The search process is illustrated in Figure 1, and the final set of articles is listed in Table 1.
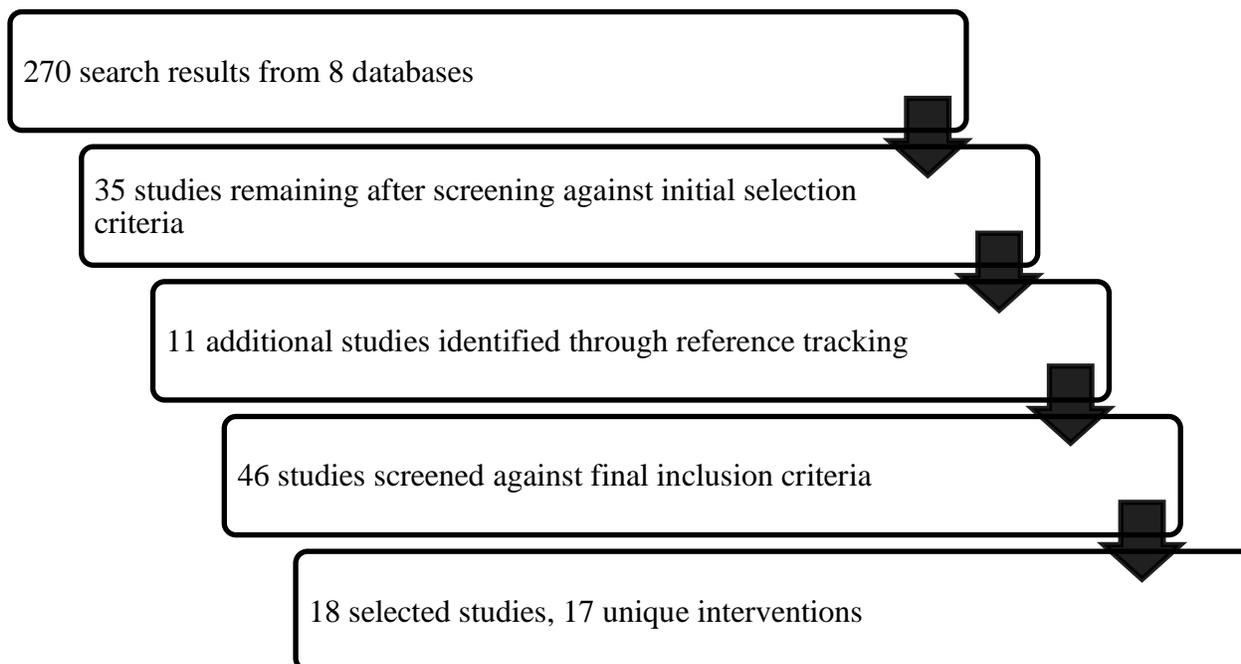
Figure 1
Search Process

Table 1

Reviewed Studies

Author and Year	Journal
Antoniou & Souvignier, 2007	*Learning Disabilities: A Contemporary Journal*
Cleary et al., 2017	*Journal of School Psychology*
Dresel & Haugwitz, 2008	*The Journal of Experimental Education*
Festas et al., 2015	*Contemporary Educational Psychology*
Fidalgo et al., 2008*	*Contemporary Educational Psychology*
Gidalevich & Kramarski, 2019	*Instructional Science*
Hacker et al., 2015	*Reading and Writing Quarterly*
Minnaert et al., 2017	*Frontiers in Education*
Sanz et al., 2003	*European Journal of Psychology of Education*
Schunemann et al., 2013	*Contemporary Educational Psychology*
Schunemann et al., 2017	*Instructional Science*
Sontag & Stoeger, 2015	*Learning and Individual Differences*
Souvignier & Mokhlesgerami, 2006	*Learning and Instruction*
Sporer & Schunemann, 2014	*Learning and Instruction*
Stoeger et al., 2014	*Journal of Educational Psychology*
Torrance et al., 2007	*Learning and Instruction*
Vandevelde et al., 2017	*The Journal of Educational Research*
Wagner & Perels, 2012	*International Scholarly Research Network Education*

*Study contained an additional delayed follow-up for the intervention in Torrance et al. (2007).

Data Analysis

Articles were read in full and analyzed through an extensive coding scheme. In addition to authors, publication year, and journal, codes related to RQ1 included research design, type of data, participants, setting, domain, nature of control group, treatment conditions, duration of intervention, length of delay before follow-up measures, SRL measures, achievement measures, implementers of intervention, training provided for implementers, intervention components and materials, intervention instruction and timing, and use of existing or prescribed intervention programs. Codes related to RQ2 included SRL results, achievement results, and additional results. Additional codes were used to evaluate the methodological rigor and limitations of studies, including assignment to groups, attrition, equivalency of groups, monitoring fidelity of implementation, additional threats to external validity, additional threats to internal validity, and additional limitations identified by authors.

Results

The majority of the studies were from well-regarded journals with strong metrics. For example, three articles were from *Contemporary Educational Psychology*, and an additional three articles were found in *Learning and Instruction*, which each have an acceptance rate of 13% according to Cabell's International and have 2020 impact factors of 4.277 and 5.146, respectively. However, because the review aims to be comprehensive, no journals were excluded. The studies were rigorous and most utilized a quasi-experimental design with random assignment of intact classrooms and incorporated control or comparison groups without

intervention. Exceptions from these standards are discussed in more detail in the following subsections. Results are further presented in response to each research question.

Research Question 1: What trends are present in SRL intervention studies that include follow-up measures?

Some salient trends were present amongst the reviewed studies. These will be addressed in the following subsections.

Research Designs and Treatment Conditions

As noted, the reviewed studies were almost exclusively quasi-experimental in design. One notable exception is Cleary et al. (2017), a true experimental study. Another exception is Fidalgo et al. (2008), which is an additional delayed follow-up using some individuals from a previous treatment group from another reviewed study (Torrance et al., 2007) but a newly sampled comparison group. Additionally, all included studies utilized quantitative data for analysis, including quantified scores and frequency counts from open-ended data and think-alouds in some cases. Only one study lacked a comparison group (Gidalevich & Kramarski, 2019). Comparison conditions are listed in Table 2.

The reviewed studies most frequently included one treatment group receiving an SRL intervention and compared them to a control group with unaltered classroom instruction or, in other words, a "business as usual" (BAU) control group ($n = 8$) (Dynarski, 2016). However, several studies did include two treatment groups ($n = 7$). Of these, four studies included a treatment group receiving only content strategy instruction in addition to a treatment group receiving the same content strategy instruction combined with SRL training (Schunemann et al., 2013; Schunemann et al., 2017; Stoeger et al., 2014; Wagner & Perels 2012). Each of these also included a no-treatment comparison group. Other studies included a treatment group that received strategy training that addressed only a component related to SRL, in addition to a treatment group receiving that same strategy training within a holistic SRL intervention (Dresel & Haugwitz, 2008; Minnaert et al., 2017). The remaining study with two treatment groups did not incorporate a control condition and instead compared an intervention group with fixed scaffolds to one with scaffolds that were gradually removed (Gidalevich & Kramarski, 2019). Studies with three treatment groups each included one treatment group receiving a holistic SRL intervention including content strategies, which was compared to a treatment group receiving only content-strategy instruction and a treatment group receiving content-strategy instruction combined with a component of SRL (Souvignier & Mokhlesgerami, 2006; Sporer & Schunemann, 2014). Treatment conditions are listed in Table 2.

Table 2
Conditions

Author and Year	Treatment Condition	Control Condition
Antoniou & Souvignier, 2007	1 treatment group receiving SRL intervention	BAU
Cleary et al., 2017	1 treatment group receiving SRL intervention	BAU
Dresel & Haugwitz, 2008	2 treatment groups: 1 received attribution feedback, 1 received feedback and metacognitive control questions	Control group worked with the same math software with no feedback or metacognitive questions
Festas et al., 2015	1 treatment group receiving SRL intervention	BAU
Fidalgo et al., 2008*	1 treatment group receiving SRL intervention	BAU
Gidalevich & Kramarski, 2019	2 treatment groups receiving SRL interventions: 1 group had consistent prompts, 1 group had faded prompts	No control group
Hacker et al., 2015	1 treatment group receiving SRL intervention	BAU
Minnaert et al., 2017	2 treatment groups: 1 received self-regulated strategy instruction (SRSD), 1 combined this with behavioral support	BAU
Sanz et al., 2003	1 treatment group receiving SRL intervention	BAU
Schunemann et al., 2013	2 treatment groups: 1 group received a reading strategies intervention, 1 group received reading strategies combined with SRL	BAU
Schunemann et al., 2017	2 treatment groups: 1 group received reciprocal teaching (RT) intervention, 1 group combined this with SRL	BAU
Sontag & Stoeger, 2015	1 treatment group receiving SRL intervention	BAU
Souvignier & Mokhlesgerami, 2006	3 treatment groups: 1 group receiving a reading strategies intervention, 1 group combining that with cognitive self-regulation, and 1 group combining reading strategies with cognitive and motivational self-regulation	BAU
Sporer & Schunemann, 2014	3 treatment groups: 1 group receiving reciprocal teaching (RT) combined with strategy implementation, 1 group combining reciprocal teaching with outcome regulation, and 1 group combining all components	Control group receiving reciprocal teaching program
Stoeger et al., 2014	2 treatment groups: 1 group receiving text reduction intervention, 1 group combining that with SRL training	BAU
Torrance et al., 2007	1 treatment group receiving SRL intervention	BAU
Vandevelde et al., 2017	1 treatment group receiving SRL intervention via tutoring	Control group not receiving tutoring
Wagner & Perels, 2012	2 treatment groups: 1 group receiving translation instruction, 1 group combining that with SRL training	BAU

Populations Under Study

This review was restricted to K-12 populations, but within that constraint, there are still variations regarding the participants, which are detailed in Table 3. Participants ranged from 4th grade to 10th grade, with each grade in between represented in at least one study. The highest proportion of studies were completed with an elementary population ($n = 9$) and a middle or junior high school population ($n = 8$), with some studies including multiple grade levels and thus reflected in both counts. There were fewer studies completed with high school participants ($n = 2$). Grade levels refer to the status of participants at the time of the intervention rather than at follow-up. Sample sizes ranged from 40 to 763, with the majority of studies including over 100 participants. Most of the studies focused on participants with no special demographic characteristics and described students as typical. However, five studies included more unique populations based on demographics, socioeconomic status, or academic risk factors such as learning disabilities or low grades in a subject area.

Table 3
Study Samples

Author and Year	Number of Participants	Participant Grade	Special Characteristics
Antoniou & Souvignier, 2007	73	5th, 6th, 7th, 8th	Learning disabilities
Cleary et al., 2017	42	7th	Low math scores and/or lacking motivation (teacher-reported)
Dresel & Haugwitz, 2008	151	6th	None
Festas et al., 2015	380	8th	None
Fidalgo et al., 2008*	77	6th	None
Gidalevich & Kramarski, 2019	134	4th	None
Hacker et al., 2015	393	7th	Title 1 schools, most eligible for free or reduced lunch
Minnaert et al., 2017	249	9th	Prevocational
Sanz et al., 2003	40	8th	None
Schunemann et al., 2013	323	5th	None
Schunemann et al., 2017	244	5th	None
Sontag & Stoeger, 2015	322	4th	Students without migration background
Souvignier & Mokhlesgerami, 2006	593	5th	None
Sporer & Schunemann, 2014	535	5th	None
Stoeger et al., 2014	763	4th	None
Torrance et al., 2007	95	6th	None
Vandevelde et al., 2017	401	5th, 6th	Majority students of low socioeconomic or immigrant background
Wagner & Perels, 2012	109	10th	None

Intervention Structure

The studies under review all included an SRL intervention, but the contexts, timeframe, and structure of these interventions vary; details for individual studies are included in Table 4. The majority of interventions were situated within a specific domain, with the most frequent being reading ($n = 7$), followed by writing ($n = 4$) and math ($n = 3$). Most interventions were also implemented during class, even when implemented by researchers rather than teachers. One notable exception is the intervention implemented by Vandevele et al. (2017), which took place during tutoring sessions. Interventions also ranged in frequency and length of intervention sessions as well as the duration of the overall implementation period. Intervention sessions ranged from 30 minutes to two hours in length, with 45 minutes as the most commonly reported amount of time. Studies reported sessions taking place from one time per week to daily. Overall durations of interventions ranged from three weeks to two years. The length of time between the end of the duration and the time of the delayed follow-up measure ranged from the initial inclusion criteria of eight weeks up to 28 months.

Table 4
Intervention Structure

Author and Year	Domain	Duration	Time Between Posttest and Follow-Up
Antoniou & Souvignier, 2007	Reading	One academic year	3 months
Cleary et al., 2017	Math	4 months	2 months
Dresel & Haugwitz, 2008	Math	5 months	5 months
Festas et al., 2015	Writing	4 months	2 months
Fidalgo et al., 2008	Writing	10 weeks	28 months
Gidalevich & Kramarski, 2019	Math	7 weeks	3 months
Hacker et al., 2015	Writing	6 weeks	2 months
Minnaert et al., 2017	Writing	3 months	1 year
Sanz et al., 2003	Not-domain specific	Two academic years	Two years
Schunemann et al., 2013	Reading	7 weeks	8 weeks
Schunemann et al., 2017	Reading	8 weeks	8 weeks
Sontag & Stoeger, 2015	Reading and science	7 weeks	11 weeks
Souvignier & Mokhlesgerami, 2006	Reading	4 months	5 months
Sporer & Schunemann, 2014	Reading	8 weeks	8 weeks
Stoeger et al., 2014	Reading and science	7 weeks	11 weeks
Torrance et al., 2007	Writing	10 weeks	12 weeks
Vandevelde et al., 2017	Not-domain specific	3 months	2 months
Wagner & Perels, 2012	Latin	3 weeks	8 weeks

Note. Language used in the table is based on the authors' language in the original studies.

Common Intervention Programs

Several studies utilized existing intervention designs which they implemented or adapted for their studies. Three studies incorporated a writing intervention using the Self-Regulated Strategy Development (SRSD) framework developed by Harris and Graham (1996) (Festas et al., 2015; Hacker et al., 2015; Minnaert et al., 2017). Three other studies utilized the same Reciprocal Teaching (RT) framework developed by Palincsar and Brown (1984) for the content strategy component of their interventions and appeared to share many common components within the SRL elements of their interventions as well (Schunemann et al., 2013; Schunemann et al., 2017; Sporer & Schunemann, 2014). Two other studies employed an intervention framework developed by Stoeger and Zeigler (2008) (Sontag & Stoeger, 2015; Stoeger et al., 2014). Other existing frameworks used in single studies included the Self-Regulation Empowerment Program (SREP) designed by Cleary & Platten (2013) and IMPROVE metacognitive prompts developed by Mevarech and Kramarski (1997) (Cleary et al., 2017; Gidalevich & Kramarski, 2019). Other interventions were developed for studies by the authors, all of whom extensively cited SRL research.

Intervention Components

SRL interventions tended to involve a combination of teaching approaches, including combinations of direct instruction, teacher modeling and examples, in-class activities and tasks to facilitate guided practice, class discussion, interactive in-class games, and independent work on assignments. Interventions also often included tools to remind students about processes involved in SRL, such as cards, help sheets, mnemonic devices and charts, graphs, visual aids such as posters, and prompts within class content assignments and homework. These supplementary materials were sometimes just external aids to encourage students to engage in SRL processes. At other times, they were tools students had to use tools such as worksheets, logbooks, journals, and diagrams that required students to set written goals, monitor progress, plan and track strategy use, reflect on feedback, evaluate performance, and describe adaptations. Interventions typically followed a set schedule and introduced different components of SRL on a timeline, and some interventions reduced SRL scaffolding over time to encourage students to engage in the processes more autonomously. Interventions differed in complexity, but most were intricate and involved many components and tools in concert. One intervention which deviated from this pattern was implemented by Dresel and Haugwitz (2008). This simplified intervention required students to answer questions that were designed to support metacognitive control as they worked on math exercises. Students were also provided computer-generated attributional feedback alongside their scores. Some studies included clear information about the intervention's theoretical basis, topics, and learning objectives, but offered only limited descriptions of the actual intervention implementation, which made them more difficult to compare to others (Sanz et al., 2003; Wagner & Perels, 2012).

The use of group work in interventions to support shared or co-regulation of learning was less consistent than some other characteristics across studies. Six studies explicitly mentioned group, team, or partner work and/or peer feedback or discussions as a component of the intervention; three of these studies used a common intervention framework which incorporates rotating roles within small group activities (Schunemann et al., 2013; Schunemann et al., 2017; Sporer & Schunemann, 2014). An additional two studies involved interventions that took place exclusively in a small group format: Vandevelde et al. (2017) implemented an intervention through small group tutoring, and Cleary et al. (2017) used a small group coaching format. It is

possible that additional interventions involved small group work during some of the included activities and did not explicitly differentiate group activities from individual activities.

Intervention Implementation

Interventions were most often implemented by existing teachers within their classrooms, but in multiple other studies, researchers or research assistants implemented the intervention. Exceptions included one intervention which was implemented by a handful of trained school employees, such as counselors, and one intervention that was facilitated by trained graduate student tutors with some supervision from classroom teachers (Cleary et al., 2017; Vandevelde et al., 2017). All studies utilizing teachers or school employees for implementation included training, with the exception of Dresel and Haugwitz (2008), which was heavily computer-based. Most trainings were reported to be several hours long and often over multiple days. They typically included materials for use during implementation, such as manuals containing sequences, structure, and guidelines for the intervention. Many authors also described ongoing meetings with teachers and school employee facilitators for support and training ranging from one additional meeting to weekly meetings throughout the implementation period. Some researchers also utilized checklists which served to aid facilitators in correctly implementing the intervention as well as offer evidence of fidelity for researchers. Other means of monitoring fidelity of implementation included periodic observations, facilitator notes and reports of sessions, and analysis of student materials for task completion.

Measures

Most studies included measures of both SRL and academic achievement; measures for all studies are listed in Table 5. In multiple studies, SRL was measured exclusively via student self-report measures, often primarily Likert-style rating scales. Other studies included a variety of other measurement forms for SRL, often in combination with one or more self-report scales. Some less complex additional measures included a calculation of calibration accuracy, a teacher self-report scale, and multiple-choice tests to assess understanding of content strategies. Other measures of SRL were more expansive, such as process logs, a think-aloud, and coding open-ended responses to reading tasks, scenario-based questions, or after an exam. The majority of studies that included measures beyond self-report scales also triangulated SRL data across multiple measures, with the exception of Schunemann et al. (2017) and Torrance et al. (2007).

While studies included similar theoretical frameworks for their research, there is variation in how SRL was measured beyond the type of instrument employed. Some studies included one measure or a combination of measures that addressed all major phases and multiple subprocesses of SRL. Measures assessed subprocesses such as motivation, self-efficacy, self-concept, metacognition, metacognitive control, understanding and application of cognitive strategies, calibration, and attributions; however, the included subprocesses assessed were inconsistent from study to study. Studies which included a comprehensive measure to assess all phases of SRL also revealed few commonalities, with only one questionnaire being utilized in two different studies: the Questionnaire of Self-Regulated Learning-7, developed by Ziegler et al. (2010), was used by both Stoeger et al. (2014) and Sontag & Stoeger (2015). Other studies that measured SRL only included measures addressing a relatively small portion of SRL subprocesses. For instance, Minnaert et al. (2017) assessed only goal orientation. Other studies included a measure of domain-specific strategy knowledge or application along with a measure of self-efficacy or

motivation (Antoniou & Souvignier, 2007; Schunemann et al., 2013; Sporer & Schunemann, 2014).

Achievement measures in the reviewed studies typically consisted of one or two content tests and included both multiple-choice and open-ended measures. Most reading and math measures were standardized, but some reading measures involved longer responses and were analyzed for correctly identified main ideas. Writing tasks were scored for a variety of elements, including structure, coherence, quality, word counts, paragraphs included, and structural elements included. Researchers utilizing open-ended measures of achievement reported at least a portion of responses being scored by two or more independent raters. One writing measure was scored by an automated essay-scoring system (Hacker et al., 2015). Only one study incorporated course grades as a measure of achievement (Sanz et al., 2003).

Table 5
Measures

Author and Year	SRL Measures	Achievement Measures
Antoniou & Souvignier, 2007	Reading-strategy knowledge task (students had to "grade" strategy use of others); Reading self-efficacy	General intelligence; Vocabulary knowledge; Decoding speed; Reading comprehension (multiple choice and open-ended)
Cleary et al., 2017	SRL scale; Hypothetical test preparation scenario; Microanalytic attributions; Microanalytic adaptive inferences; Self-efficacy for self-regulated learning	Mathematics standardized exams
Dresel & Haugwitz, 2008	Internality of success attributions; Stability of failure attributions; Ability self-concept; Helplessness scale; Metacognitive Control Strategies	Math achievement (researcher-developed based on the official mathematics curricula)
Festas et al., 2015	None	Writing, opinion essay task (scored for number of words and for number of structural elements)
Fidalgo et al., 2008	Writing metaknowledge/motivation open-ended questionnaire (coded for substantive processing, low-level processing, ability, and motivation); Writing self-efficacy; Writing processes log	Writing quality (scored for structure, coherence, and general quality); Number of paragraphs and words and introductory and concluding paragraphs
Gidalevich & Kramarski, 2019	Metacognitive Awareness; Calibration judgments; Motivation (achievement goals)	Standardized math achievement test

Author and Year	SRL Measures	Achievement Measures
Hacker et al., 2015	None	Persuasive essay task (scored using an automated essay scoring system)
Minnaert et al., 2017	Goal Orientation Questionnaire	None
Sanz et al., 2003	Learning Strategies (to measure frequency of use of metacognitive strategies)	General intelligence; Average grades in mathematics, language, and natural sciences
Schunemann et al., 2013	Self-efficacy for reading; Strategy-related task performance activity (coded for strategy use)	Reading comprehension; Reading fluency
Schunemann et al., 2017	Strategy-related task performance activity (coded for strategy use)	Reading comprehension
Sontag & Stoeger, 2015	Preference for SRL	Main ideas (number of correct main ideas identified in training materials)
Souvignier & Mokhlesgerami, 2006	Reading strategies test; Open-ended application of reading strategies task (scored for correct strategy application); Self-efficacy; Motivational learning goal orientation	Reading comprehension
Sporer & Schünemann, 2014	Reading strategy application task (coded for quality); Reading motivation	Reading comprehension; Reading fluency
Stoeger et al., 2014	Preference for SRL	Reading comprehension; Main ideas (number of correct main ideas identified in training materials)
Torrance et al., 2007	Writing processes log	Writing quality (scored for structure, coherence, and general quality); Number of words and number of paragraphs by type.
Vandevelde et al., 2017	Teacher rating scale; SRL scale Think-aloud protocols	None
Wagner & Perels, 2012	SRL scale	Latin translation test

Research Question 2: Do SRL interventions have lasting effects on students' achievement and self-regulated learning

Results of the reviewed studies are included in Table 6. Of the studies that included a delayed measure of achievement, results for the majority ($n = 12$) indicated lasting effects on students' achievement after a delay. Only two interventions deviated from this pattern; results for each indicated significant effects on achievement at an initial posttest, but these did not remain after a delay (Dresel & Haugwitz, 2008; Stoeger et al., 2014). While some of the successful

interventions resulted in similar effects at an initial posttest, in other studies ($n = 5$), significant differences did not emerge between the holistic SRL intervention treatment group and a control group until a delayed posttest (Antoniou & Souvignier, 2007; Hacker et al., 2015; Schunemann et al., 2017; Souvignier & Mokhlesgerami, 2006; Sporer & Schunemann, 2014). Gidalevich & Kramarski (2019) did not include a control group in their study and similarly did not report statistically significant within-group changes at an initial posttest, but did after a delay.

Results of a few studies indicated lasting effects on student achievement with a holistic SRL intervention and included an additional treatment group targeting only content strategies; in each of these studies, the holistic intervention treatment group significantly outperformed or improved achievement more than the group receiving only strategy instruction (Schunemann et al., 2013; Schunemann et al., 2017; Wagner & Perels, 2012). In other studies showing durable achievement results, additional treatment groups varied regarding the phases of SRL that were supported in the intervention; however, results did not follow a clear pattern wherein the most comprehensive intervention led to the strongest achievement results (Souvignier & Mokhlesgerami, 2006; Sporer & Schunemann, 2014). In Souvignier and Mokhlesgerami's (2006) study, while the holistic SRL treatment group did outperform a control group at a delay, it had no statistically significant differences from the group receiving only strategy instruction or the groups receiving strategy instruction combined with less comprehensive SRL interventions. In Sporer and Schunemann's (2004) study, students in the holistic SRL treatment group outperformed students receiving only reading strategy instruction but did not have higher achievement scores than treatment groups which supported only one or two phases of SRL. Overall, of the holistic SRL interventions resulting in long-term effects on achievement, most featured inclusion of domain-specific strategy instruction.

Of the studies that included a delayed measure of SRL, the majority ($n = 14$) indicated lasting effects on one or more components of students' SRL after a delay. Only one study measured SRL after a delay and provided no significant effects (Vandevelde et al., 2017). Studies differed greatly in the extent to which SRL was assessed, including how many measures were utilized and how many SRL processes were measured. Some studies included only a singular, close-ended self-report instrument designed to assess all phases of SRL; data from each of these studies suggested lasting effects on students' SRL (Sanz et al., 2003; Sontag & Stoeger, 2015; Stoeger et al., 2014; Wagner & Perels, 2012). Other researchers utilized a combination of measures to address all phases of SRL; each of these studies resulted in mixed findings at a delay, rather than exclusively positive findings for all components of SRL (Cleary et al., 2017; Fidalgo et al., 2008; Gidalevich & Kramarski, 2019; Torrance et al., 2007). Other researchers explored only limited components of SRL rather than including measures for each phase. Some of these studies similarly had mixed results for different components of SRL after a delay (Minnaert et al., 2017; Souvignier & Mokhlesgerami, 2006; Sporer & Schunemann, 2014). However, other studies addressing limited components of SRL found exclusively positive results for all the components examined (Antoniou & Souvignier, 2007; Dresel & Haugwitz, 2008; Schunemann et al., 2013; Schunemann et al., 2017). Three studies included treatment groups targeting only parts of SRL in addition to a holistic SRL intervention (Dresel & Haugwitz, 2008; Souvignier & Mokhlesgerami, 2006; Sporer & Schunemann, 2014). None of these studies showed the holistic SRL intervention having significantly stronger results regarding SRL at a delayed follow-up on all measures of SRL, but they did show stronger results on some measures.

Table 6

Study Results

Author and Year	Results	
	Posttest	**Follow Up**
Antoniou & Souvignier, 2007	No significant differences on reading comprehension; Treatment group significantly increased reading strategy knowledge compared to control; No significant differences on reading self-efficacy.	Treatment group had significantly higher reading comprehension; Treatment group had significantly increased reading-strategy knowledge and reading self-efficacy compared to the control.
Cleary et al., 2017	No significant differences in math achievement; Treatment group had significantly higher scores for microanalytic attributions and adaptive inferences and test preparation; No significant differences on self-efficacy or maladaptive regulatory behaviors.	No significant differences in math achievement; Treatment group maintained significantly higher scores for microanalytic attributions and adaptive inferences; No significant differences on self-efficacy, maladaptive regulatory behaviors, or test preparation.
Dresel & Haugwitz, 2008	Both treatment groups had significantly greater increase in math knowledge and motivation than control; Combined treatment group had significantly higher metacognitive control than the attributional feedback and control conditions;	No significant differences on math knowledge; Combined treatment group had significantly higher metacognitive control than the attributional feedback and control conditions; Both treatment groups had significantly higher motivation than control.
Festas et al., 2015	Treatment group had significantly greater improvements in writing.	Treatment group had significantly greater improvements in writing.
Fidalgo et al., 2008	Posttest results from Torrance et al. (2007): Treatment group had significantly greater increase in time on task and time spent planning than control; No significant differences for revising. *Within-group results:* Treatment group significantly increased text quality	Treatment group had significantly higher quality writing; Treatment group had significantly higher time spent planning and metaknowledge of text structure; No significant differences on revisions or self-efficacy.
Gidalevich & Kramarski, 2019	No significant differences on math; No significant differences on SRL measures.	Faded treatment group had significantly higher math scores than fixed treatment group (no control group). Faded treatment group had significantly higher scores than fixed treatment group on some SRL measures: knowledge of cognition, mastery goal and performance-approach goal orientation; Fixed treatment group had significantly more accurate confidence judgments than faded treatment group.
Hacker et al., 2015	No significant differences on writing scores.	Treatment group had significantly higher writing scores.

Author and Year		Results
Minnaert et al., 2017	Mainly modest declines in motivation across groups.	Significantly less decline in motivation for combined treatment group on task orientation, ego-enhancing orientation, and ego-defeating orientation than control; For the strategy instruction only, ego orientations showed significantly less decline than control.
Sanz et al., 2003	Treatment group had significantly higher scores for general intelligence and academic achievement; Treatment group had significantly higher frequency of use of metacognitive strategies.	Treatment group had significantly higher scores for general intelligence and academic achievement; Treatment group had significantly higher frequency of use of metacognitive strategies.
Schunemann et al., 2013	Both treatment groups had significantly higher reading comprehension than control, but treatment groups did not differ; Both treatment groups had significantly higher strategy-related task performance and reading self-efficacy than control, but treatment groups did not differ.	Both treatment groups had significantly higher reading comprehension than control, and the combined treatment group had significantly higher reading comprehension than the RT treatment group; Both treatment groups had significantly higher strategy-related task performance and reading self-efficacy than control, and the combined treatment group had significantly higher strategy-related task performance than the RT treatment group.
Schunemann et al., 2017	No significant differences on reading comprehension.	Combined SRL treatment group had significantly higher quality feedback and significantly more improved strategy-related task performance than the RT-only treatment group.
Sontag & Stoeger, 2015	*Within-group results:* Treatment group including high achieving subgroup, average achieving subgroup, and average intelligence subgroup, had significantly increased self-reported SRL; Treatment group including all subgroups had significantly increased scores for correctly identified main ideas.	*Within-group results:* Treatment group, including all subgroups, had significantly increased self-reported SRL.
Souvignier & Mokhlesgerami, 2006	Comprehensive combined treatment group had significantly greater effects for reading comprehension compared to control; Partially combined treatment group had significantly higher understanding of reading strategies and significantly reduced learning goal orientation compared to control; No significant differences between treatment and control groups for self-efficacy.	Comprehensive combined treatment group had significantly higher reading comprehension compared to control; Comprehensive combined treatment group had significantly higher understanding of reading strategies and application of reading strategies compared to control; No significant differences between treatment and control groups for self-efficacy.

Author and Year		Results
Sporer & Schunemann, 2014	No significant differences for reading strategies or motivation.	All treatment groups had significantly higher reading comprehension than control; Combined SRL treatment group and strategy implementation treatment group had significantly higher reading strategy scores compared to the outcome regulation treatment and control groups; Outcome regulation treatment group had significantly higher motivation than the combined SRL treatment.
Stoeger et al., 2014	When migration data was included as a predictor, the combined treatment group had significantly higher reading comprehension scores than the text reduction treatment and control groups; The combined group had a significantly higher preference for SRL and identified significantly more main ideas than other groups.	No significant differences for reading comprehension; The combined group showed a significantly higher preference for SRL than other groups.
Torrance et al., 2007	Treatment group had significantly greater increase in time on task and time spent planning than control; No significant differences for revising. *Within-group results:* Treatment group significantly increased text quality.	Treatment group had significantly greater increase in time on task and time spent planning than control; No significant differences for revising *Within-group results:* Treatment group sustained increased text quality.
Vandevelde et al., 2017	Treatment group had a significantly greater increase in teacher-rated SRL and significantly lower decrease in external regulation and memorizing compared to control.	Treatment group had a significantly greater decrease in teacher-rated SRL; No significant differences on self-reported or think-aloud measures of SRL.
Wagner & Perels, 2012	Both treatment groups had a significantly greater increase in translation competency and translation strategy application than control group; Both treatment groups had significantly higher SRL scores than control group.	*Within-group results:* The combined treatment group maintained translation competency and translation strategy application; The translation-only treatment group significantly decreased in translation competency and strategy application.

Note. Results included in the table are between-group results unless otherwise noted.

Discussion

This review evaluated studies that include holistic SRL interventions targeting all phases of SRL and were intended to improve students' SRL or academic achievement. Because this review focused on the durability of effects of SRL interventions, only studies with a delayed follow-up measure that took place at least eight weeks following the intervention period were included. The studies are further restricted to K-12 populations. These studies included a wide range of participants from elementary to high school grade levels, including both typical student populations and populations with more specific characteristics typically related to academic risk. Studies generally included large sample sizes, and researchers executed rigorous, quasi-

experimental designs. The holistic SRL interventions tended to be complex, multi-faceted, and lengthy interventions typically implemented in classroom settings and within core academic domains. Given the quality of the identified studies, conclusions drawn from compiled results can be viewed as strong empirical evidence for the effectiveness of such interventions.

These studies included mainly positive outcomes related to SRL variables after a delay and overall indicate that SRL interventions can have a lasting impact on students' self-regulation, though results were mixed in several studies that included multiple measures of SRL. There were many differences in how SRL was operationalized and assessed due to the variety of subprocesses subsumed by SRL, which made it difficult to draw conclusions regarding the specific contributing factors that led to these results beyond the general trends amongst the interventions previously described. Other researchers have similarly noted the challenges in measuring SRL and variations between studies (Rovers et al., 2019).

Achievement results from these interventions were also largely positive after a delayed follow-up measure and were more readily synthesized. After examining the durability of intervention effects on achievement, one can conclude that holistic SRL interventions do often have lasting effects on student achievement, at least within the content area in which they were implemented. Furthermore, one study included a widespread intervention and showed lasting positive effects on a global measure of achievement, but this was not replicated in other studies (Sanz et al., 2003). Enduring achievement effects occurred across multiple domains, including reading, writing, math, and foreign language. These results were present for typical students, at-risk populations, and across grade levels. This pattern of effects on achievement across domains and populations illustrates the flexibility of these interventions to improve student success in a variety of contexts and without exacerbating existing achievement gaps.

Another pattern from the reviewed studies indicates that combining SRL strategies with domain-specific strategy instruction leads to better long-term achievement outcomes than domain-specific strategies alone (Schunemann et al., 2013; Schunemann et al., 2017; Sporer & Schunemann, 2014; Wagner & Perels, 2012). This is an important implication for our classrooms, where instructors may focus on one domain at a time. Although students may receive a great deal of instruction regarding domain-specific strategies, they may consequently be provided with less emphasis on strategies that are transferable across domains.

Finally, while most researchers that assessed achievement after a delay reported positive effects of holistic SRL interventions on achievement, several of these studies did not have the same results at an immediate posttest; rather, they did not see these effects emerge until the delayed follow-up. This finding implies that in some instances, the effect of holistic SRL interventions on academic achievement may not be realized until a delay, at which time many educators and administrators may have failed to continue to evaluate lingering effects and prematurely abandoned the SRL programs.

Overall, this review supports the assertion of other researchers that holistic SRL interventions have the potential to induce lasting effects on students' achievement. Hacker and Bol (2019) described a similar pattern supporting holistic interventions on metacognitive judgments and achievement; however, they did not focus on the durability of findings or differences across domains. Dignath and Buttner (2008) did address durability and concluded from their meta-analysis that longer SRL interventions were generally more effective for primary and secondary school students. Similarly, another review (de Boer et al., 2018) did focus on long-term effects but more broadly included interventions involving metacognitive strategy instruction. de Boer et al. (2018) reported that student achievement generally improved following

the intervention and that these improvements were sustained and sometimes increased further after a delay.

While the studies reviewed here generally did not address transfer from one academic domain to another, and most achievement results are domain-specific, such results consistently occurred across domains. This suggests that similar supports could be implemented in a wide variety of classes, subjects, and domains and lead to improved student success. While domain-specific learning strategies are already being utilized within K-12 education, these results lend support for the implication that combining SRL training and domain-specific strategies can lead to better achievement outcomes in the long term.

Results of this review translate into practical implications for educators. Designers and instructors should include comprehensive SRL supports in various domain areas. There is a need for more SRL support in our K-12 schools. If these interventions seem to work and lead to lasting effects, they should be incorporated frequently. Additionally, SRL is an important predictor of academic achievement in college environments as well (Dorrenbacher & Perels, 2016). Fostering SRL in earlier grades can have long-term benefits and help prepare students for continued academic success as they advance to postsecondary education.

Limitations of Studies Reviewed

The reviewed studies are not without limitations, many of which were identified by the authors themselves. Regarding methodology, the researchers typically utilized quasi-experimental designs. Although intact classrooms were generally randomly assigned to conditions, there was not true random assignment of participants to treatment and control groups. Selection bias cannot be ruled out completely as a potential confound. Also, in most studies, the control group was a "business as usual" condition, which limits clarity of conclusions given that it is not a true control condition (Dynarski, 2016). This is particularly salient when few details are provided regarding the BAU condition or when comparison groups are selected from classes taught by different teachers or from different schools, as occurred in many of the reviewed studies.

There are also limitations regarding the fidelity of implementation of interventions. While most studies described steps taken to monitor and assess fidelity, these ranged in rigor, such as whether they included frequent observations or relied on few or no observations and instead focused on teacher self-reports. In other studies, the intervention was implemented by researchers or trained assistants; while this may improve the fidelity of implementation, it reduces the ecological validity of the studies (Schunemann et al., 2013).

Another limitation is the frequent reliance on self-report measures to assess SRL. While there were some other creative approaches utilized, such as process logs, think-alouds, and analysis of writing tasks and other artifacts, these kinds of additional measures were less frequent, leading to a lack of triangulation of SRL data as well as the potential for self-report biases (Rovers et al., 2019). Also, as previously discussed, there was variation among studies in the components of SRL targeted and the instruments utilized.

Gaps remaining in the literature become clear when examining the trends amongst the studies. There is a lack of exploration of the transfer of SRL skills across academic domains, with most interventions implemented and evaluated in only one domain. Most studies also took place with typical student populations resulting in less information regarding at-risk, neurodiverse, or ELL students.

Limitations of Present Review

There are also limitations of this systematic review. The review includes a relatively small number of articles, and only articles available in English were selected. The review also excludes gray literature, further limiting the scope. An additional challenge of the present review concerns the complex nature of SRL. SRL is broad and encompasses many phases and subprocesses (Zimmerman, 2002). It is difficult to measure SRL comprehensively, and there are a multitude of ways to approach assessment (Rovers et al., 2019). There are also myriad options for interventions designed to target different combinations of subprocesses, and SRL is applicable in all different content areas. Because of these complexities, it can be difficult to make clear comparisons between studies which lack commonalities in measurement and intervention design.

Suggestions for Further Research

Authors of the reviewed studies had several suggestions for future research. They described extending research to other populations of grade levels and demographics, utilizing larger sample sizes, and including more treatment groups. Researchers also recommended including additional measures to address more components of SRL and to move beyond self-report measures. Authors discussed the need for additional interventions of varying structures of time blocks and implemented by teachers rather than researchers. The need for more observation of treatment groups was also noted, including video recordings and observations of control groups.

The present authors agree with these identified areas for ongoing research. Increased monitoring of fidelity via observations would improve the rigor of future studies. Further, frequent observations of control groups would improve studies as well. Observations could also be a vehicle for assessing SRL and could be video recorded for in-depth analysis. Additional SRL measures are also needed in further research, such as think-aloud protocols, microanalytic measures, document analysis, and other process measures. Including more measures of SRL would consequently allow for triangulation of data to reduce bias in results. Future research could also explore long-term transfer effects of SRL and achievement in other domain areas and with global measures. Additionally, studies could include interventions that are reinforced periodically over time after the initial implementation period in comparison to those that are not to evaluate differences in durability. Also, as noted, SRL interventions were successful in many domain areas. Future research could explore interventions which are implemented in multiple domains simultaneously. Future reviews of lasting effects of SRL interventions can also be more comprehensive by including additional populations beyond K-12 as well as additional forms of literature. Ultimately, more studies which meet the inclusion criteria of this review are needed to form a larger data set to examine patterns and draw conclusions about specific intervention designs and components that are most effective in a variety of different contexts.

Although this review illustrates the potential of holistic SRL interventions to improve K-12 students' academic achievement and self-regulation of learning, knowledge is still limited due to the relative paucity of studies that include longer-term follow-up outcome measures. This dearth of research could be explained by the complexities of designing and implementing holistic SRL interventions, including the resources required. In sum, these studies can be burdensome to conduct and sponsor, yet well worthwhile in order to enhance the validity, generalizability, and durability of findings.

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