University of
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Interventions to Improve Metacognition for Children and Adolescents

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Executive Summary

Intervention studies have shown that children's metacognitive knowledge and strategies can be improved (Dignath, Büttner, and Langfeldt 2008). Consequently, there has been a growing focus on metacognition, with researchers, educators and policymakers all striving to uncover the most effective ways to best support children's metacognitive learning (Quigley, Muijs, and Stringer 2018). The prospect of developing metacognitive skills in primary and secondary years holds significant promise, as it can potentially establish a strong foundation for lifelong learning.

This report was prepared at the request of the Department for Education, Government of South Australia, to examine the evidence around interventions designed to improve metacognition in primary and secondary education. In this rapid review, we investigated whether the effectiveness of metacognition interventions is moderated by the age of the children involved, as well as other context-related factors, including the nature and duration of the intervention, the individuals delivering it and its practicality.

The results revealed a wide range and diversity of metacognition interventions in education. The sample sizes across the included studies varied significantly, with most studies featuring small samples. This variability in sample sizes raises concerns about the generalisability of findings. The central emphasis of the interventions was on improving the regulation of metacognitive processes used in learning, with varying degrees of success across different studies. The developmental level of the interventions predominantly focused on primary schools, with metacognitive development recognised as a gradual, multidimensional competence. Domain-specific interventions were more common, targeting specific academic disciplines like mathematics, while the duration of interventions varied widely from single lessons to two full school years. The interventions were primarily implemented by teachers, researchers, or collaborations between the two, each approach having its strengths and potential limitations, with the most effective outcomes often achieved through collaborations between researchers and teachers.

Overall, the quality of the science evaluating the interventions was highly variable but mostly of poor quality, with small sample sizes implemented in very specific contexts making it difficult to confidently recommend any one intervention to the Department. Of the 56 reviewed we have only recommended seven for deeper consideration. These interventions showed the greatest prospects with evidenced positive effects based on higher quality science. If the Department was interested in any of these seven, then we would recommend an adaptation and piloting process to locally evaluate how the interventions may work in the South Australian context.

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About the authors

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Professor Sally Brinkman's research aims to improve the healthy development and early learning of young children, with a focus on those living in highly disadvantaged communities. Her research is conducted across Australia, as well as countries in Asia, the Pacific, Latin America and the Emirates. She works in close partnership with international governments and donor organisations, such as the World Bank, UNICEF, and UNESCO. Sally regularly advises government and sits on numerous Expert Advisory Groups informing policy and practice. With over 200 publications, including high impact journals such as The Lancet, and her track record in achieving highly translatable research, she is well recognised nationally and internationally in both academic and policy environments.

Introduction

In the ever-evolving landscape of education, the quest for effective teaching strategies continues to be at the forefront of research and pedagogical innovation. Among the myriad of approaches, metacognition has emerged as a focal point of interest, offering a promising avenue for improving learning outcomes in children and adolescents. This rapid review investigates how learning can be enhanced through metacognitive interventions in primary and secondary education.

Metacognition, often referred to as "thinking about thinking," encompasses a range of cognitive processes that involve the awareness, regulation and control of one's own cognitive activities (Chauhan and Singh 2014; Flavell 1979; Zimmerman 1995). In the context of education, metacognitive skills empower students to become more active and autonomous learners by enabling them to plan, monitor and evaluate their own learning processes (Smith-Ferguson 2020). This heightened self-awareness and self-regulation, in turn, can lead to improved academic performance and lifelong learning skills (Quigley, Muijs, and Stringer 2018).

Metacognition in this review encompasses three primary components: metacognitive knowledge, monitoring and control. Metacognitive knowledge relates to an individual's awareness of their cognitive abilities and the discernment of when and how to apply them (Flavell 1979). Such knowledge plays a pivotal role in metacognitive monitoring, where individuals predict their performance, gauge their progress towards set objectives and evaluate the end results to enhance future performance. Integral to all these facets is control, which not only influences but is also influenced by the other components (Nelson and Narens 1990). Control, a fundamental aspect of self-regulation and executive function, dictates the cognitive and metacognitive processes employed in specific scenarios, drawing upon metacognitive knowledge and effective monitoring (Terneusen et al. 2023).

The benefits of enhancing metacognition in children and adolescents are manifold. Improved metacognitive abilities have been linked to better problem-solving skills, heightened self-efficacy, increased motivation and enhanced overall academic achievement (de Boer et al. 2018; Jacobse and Harskamp 2012; Efklides 2006). Moreover, metacognitive interventions have the potential to bridge educational disparities by providing students with tools to navigate the complexities of learning, regardless of their backgrounds or abilities. This inclusivity aligns closely with the principles of equitable education, emphasising the urgency of investigating strategies to promote metacognition within compulsory education.

However, as with any educational intervention, metacognitive strategies come with their own set of challenges and considerations. Educators and researchers must grapple with questions surrounding the most effective methods of instruction, the age-appropriateness of interventions and the adaptability of these strategies to diverse learning environments. Furthermore, the potential implementation barriers and the sustainability of metacognitive interventions in real-world classrooms require meticulous examination.

The primary objectives of this rapid review are twofold. Firstly, it aims to provide educators and policymakers with evidence-based insights into metacognitive interventions, shedding light on what works and why. By doing so, it seeks to empower them with the knowledge and tools needed to make informed decisions about incorporating metacognitive approaches into compulsory education curricula. Secondly, it underscores the broader implications of fostering metacognition among students, recognising that doing so not only enhances academic success but also equips the youth with the critical thinking skills necessary for lifelong learning and success in an ever-changing world.

Research question

Accordingly, the guiding research question for this study is: '*For children and adolescents, what interventions in a school-based setting are effective for improving metacognition?'*

Methodology

Search Process

This rapid review is based on a number of elements as detailed in the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (Larissa et al. 2015). PRISMA-P offers a standardised set of guidelines for developing and presenting systematic reviews and meta-analyses. Though systematic and rapid reviews share some congruencies – both are research synthesis methods used in evidence-based fields to gather, assess and summarise existing literature on a particular topic or research question – a rapid review's objective is to expedite the process of gathering and synthesising data, providing a more resource-efficient alternative to a full systematic review. Therefore, the review process employed in this study constrains the breadth of incorporated research studies by applying specific inclusion and exclusion criteria to a carefully selected set of databases.

Inclusion and exclusion criteria

To guide and better refine the search methodology, clear research parameters were established through consultation with South Australia's Department for Education (DfE). Initially a pilot search was conducted by experimenting with various search strings across the selected databases. After reaching consensus within the research team, the final search string was applied to a total of seven databases: A+ Education, Cochrane Library, ERIC, ProQuest, Science Direct, PubMed and Scopus. Additionally, grey literature was acquired by utilising the search string in Google's search engine to capture relevant local and international government-based reports. For a comprehensive overview of the search string and applied inclusion and applied inclusion criteria and exclusion, see Table 3 in the Appendices.

Preceding the commencement of the database search, explicit inclusion criteria for the search methodology were established. These criteria encompassed the subsequent parameters:

- Records published on or after 1 January 2003;
- Only quantitative records were considered;
- The records and metacognitive interventions were required to be available in English;
- The research had to undergo trial within a member nation of the Organisation for Economic Cooperation and Development (OECD), and;
- The interventions had to be suitable for use with children in a primary and/or secondary school setting.

Exclusion criteria were naturally derived from the inclusion criteria. For instance, qualitative records were automatically omitted as were interventions trialled outside of OECD member countries. In addition, a distinct exclusion criterion was explicitly defined for this review, which pertained to metacognitive interventions specifically tailored to or trialled with students with identified learning difficulties and/or disabilities. It is anticipated that metacognitive interventions developed for addressing the needs of students with learning difficulties and/or disabilities may be utilised to guide the scope of an additional review.

A full inventory of the inclusion and exclusion criteria used in the screening process can be found in Table 3 of the Appendix.

Screening of selected studies

A meticulous screening process was conducted to uphold the integrity of the review. Detailed statistics on inclusions and exclusions at each stage of the screening process for the seven databases are provided in Table 4 within the Appendices.

After eliminating duplicate records from the initial list, author's Smith and Brinkman initiated the first phase of the screening process. This phase involved scrutinising the title and abstract of each record to ensure its relevance to the review's central theme – namely, metacognitive interventions. Additionally, author Smith verified that each study was conducted within an OECD country and involved participants of school age (ranging from 5 to 18 years). A comprehensive list of all excluded records, along with the rationale for their exclusion, is available in Appendix 1: Databases searched and limits applied.

A total of 110 records were identified as suitable for phase two of the screening process. To streamline this stage, we evenly distributed these records between authors Smith and Terauds. Both authors conducted a comprehensive full-text review of their respective set of records, placing particular emphasis on the methodology section of each record, as this plays a critical role in data extraction. The coding process, following a framework similar to that employed by (Gascoine, Higgins, and Wall 2017), p. 11), with minor adaptations, considered several variables to determine whether records merited inclusion or exclusion. These variables encompassed the presence of complete reference details in English, a clear description of the metacognitive intervention, sample characteristics pertaining to age groups and methodological information to assess the potential for replication in primary and/or secondary school settings.

Furthermore, during the second phase, we undertook an additional step involving the retrieval of original records linked to the metacognitive interventions referenced within the initial set of records designated for review. This process also entailed identifying new interventions found in review or meta-analyses papers.

In the subsequent and final phase of the screening process, authors Gabriel, Fowler and Brinkman contributed by reviewing records to determine that the intervention explicitly included a metacognitive component, whereby each record was then coded for the type of intervention and aspect of metacognitive impact made. In effect, this ensured a double full-screening process for each record. In addition, author Brinkman provided a recommendation for each intervention based on the quality of the science and evidence hierarchy.

Evidence Hierarchy

Within science there is a hierarchy of evidence with some studies being of higher quality than others. This hierarchy typically follows a continuum of evidence quality, with the most rigorous and reliable evidence at the top and less robust evidence at the bottom. At the pinnacle of this hierarchy are systematic reviews and meta-analyses of high-quality randomised controlled trials (RCTs). These analyses offer a comprehensive and critical examination of the existing literature, making them invaluable sources for policymakers. RCTs themselves are considered the gold standard, as they involve random assignment of participants to intervention and control groups, minimising biases and providing strong causal inference.

Beneath RCTs, quasi-experimental studies and observational research come into play, providing valuable evidence but with some limitations related to potential confounding variables. Cohort and case-control studies, for instance, can offer insights into long-term effects and the relative risk of an intervention, but they may be susceptible to biases. Expert opinions and case reports occupy the lower tiers of the hierarchy, as they provide anecdotal evidence and are often subject to personal biases and limited generalisability. It is essential for policymakers to consider the entire hierarchy when evaluating interventions, as different types of evidence can collectively inform a more comprehensive understanding of an intervention's effectiveness, safety, and feasibility. Decisions should be grounded in the highest-quality evidence available while considering the practical constraints of each policy situation.

Within our review we have specifically noted the quality of the study evaluating the intervention according to the hierarchy of evidence for policy as depicted in **Error! Reference source not found.** below.

Hierarchy of Evidence for Policy

High Quality - Excellent

- Meta- Analysis (re-analyses and combines results from multiple studies)
- Systematic Reviews (summarises results from multiple studies)
- Multi-centre/site randomized controlled trials

High Quality - Very Good

- Randomised Controlled Trials
- Observational studies with causal analyses

Medium Quality - Good

- Uncontrolled or non-randomized trials
- Observational studies

Low Quality - Fair

- Pre/post studies

Low Quality - Poor

- Descriptive or qualitative studies
- Case studies
- Expert opinion

Figure 1: Hierarchy of Evidence for Policy

Evidence Quality

In addition to the hierarchy of evidence, the quality of the studies under consideration is a crucial factor to weigh. For example, it is important to recognise that not all RCTs can be automatically classified as high quality; various issues, such as inadequate sample sizes or improper data analysis, can affect the reliability of the results. Consequently, we have also conducted a thorough examination of each study's methodology, critically assessing both its position within the evidence hierarchy and the overall quality of its evaluation. This comprehensive evaluation process serves as the foundation for our decision on whether or not to recommend the intervention based on the findings presented in each of the research papers.

A summary of our reviews of each of the 56 interventions can be found in Table 1 and Table 2, with greater detail found in Appendix 2: Data Extraction Tables.

The screening process adopted in this review was both extensive and rigorous, aimed at ensuring the inclusion of pertinent and accurate studies on metacognitive interventions within OECD countries. The incorporation of specific coding criteria contributed to the robust selection of records for further analysis. This approach enhances the credibility and reliability of the review’s findings and bolsters the overall integrity of research in the domain of metacognitive interventions.

Results

The following two tables provide a comprehensive overview of the manuscripts meeting the selection process. We present the first table to provide key details for each of the interventions. This table includes the name of intervention and the study reference and provides details on the type of intervention and the aspects of metacognitive impact the authors were aiming for (for example if its aim was to impact the metacognitive skills of the individual student, regulate the environment to support metacognition, or to promote general awareness of metacognition). Further in this first table we provide basic details that are important to consider when contemplating implementation in a different setting, for example detailing who the administrator of the intervention is (e.g., teacher, psychologist/counsellor, parent), the length of time to implement the intervention, the practicality of intervention and the age range for which the intervention was targeting.

The second table aims to report on our critical review of the quality of the science being presented and if it meets a standard that would be strong enough to recommend the intervention for testing in the South Australian school system. Please note this recommendation is not based on the theoretical strength of the interventions being evaluated, it rests solely on the *hierarchy of evidence* and the *quality of the research* to determine if the intervention had any positive impact on student outcomes. Table 2 is ordered in the same way as table 1 to help the reader be able to compare across the two. For example, if an intervention looks of interest in table 1, then the reader can look-up table 2 to then review the level of evidence behind that intervention. Then further detail behind each of the interventions is provided in Appendix 2: Data Extraction Tables.

So similar to table 1, table provides the name of intervention and the reference and the provides a brief overview of the main takeaway from the studies' results, our recommendation based on the quality of the science and then some important basic information such as the sample size and the context within which the study was conducted is provided. In table 2, we also rate the study on the basis of the evidence hierarchy. Note that our review of the paper may rate the evidence differently to the way the authors described their study. For example, there were a couple of studies that described their study as randomised, however when reading the methods classes were actually selected for the intervention or not, and then the students within those classes were randomly selected for the testing. As the intervention was implemented at the class level, the classes should have been randomly allocated to intervention or not if it was to be classified as a RCT.

Note that greater details are provided in the data extraction tables within Appendix 2: Data Extraction Tables.

Table 1: Intervention details including, aspect of metacognition measured, age appropriate for, duration and aspects of practicality of implementation.

Name of Intervention	**Type of intervention**	**Aspect of metacognitive impact**	**Domain**	**Administrator**	**Duration**	**Practicality of intervention**	**Age range (yrs)**
Meta-CIC (Collaborating Inquiry Community) (Adler, Zion, and Mevarech 2016)	Improving knowledge about metacognition	Metacognitive Knowledge	Specific	Teacher	One year (included year-long open inquiry-based environmental projects)	Suitable for middle school students in a secondary setting. Length of time to deliver would most likely make it impractical for many teachers and schools.	13-14
Mental Contrasting with Implementation Intentions (MCII) (Duckworth et al. 2013)	Improving regulation of metacognition	Metacognitive Control	General	Interventionist	Three weeks (intervention)/ four school terms (outcomes measured)	Relatively simple and quick to implement, could be adapted to any age group	10-11
Training executive processes of working memory (WM) (Elosúa et al. 2013)	Improving regulation of metacognition	Metacognitive Control	Specific	Researcher	4 weeks	Suitable for primary school students; quite time-intense although over short period.	8-9
AstroWorld (Arvidsson and Kuhn 2021)	Improving regulation of metacognition	Metacognitive Knowledge and Control	Specific	Researcher	16 days (10 x 45 minute class sessions)	Suitable for Years 6 and 7 students. Computer program is scalable.	9-13

Training Program (Bianco et al. 2021)	Fostering environment that promotes metacognitive awareness	Metacognitive Knowledge	Specific	Researcher	4 weeks	Suitable to be used in a junior primary classroom and can be delivered to whole class at a time.	7-8
Learner's Toolkit (Byers et al. 2022)	Improving regulation of metacognition	Metacognitive Knowledge, Monitoring and Control	General	Teachers (secondary)	3 years (?)	Suitable for Years 7 to 10 as a comprehensive sequential program.	11 to 15
Metacognitive monitoring and control (Dörr and Perels 2019)	Improving regulation of metacognition	Metacognitive Knowledge, Monitoring and Control	General	Researchers	5 weeks	Time/resource-intensive as involved training of teachers, parents and children. Play-based methods suitable for 5–6-year-olds.	5 to 6
Training Activities (Cornoldi et al. 2015)	Improving regulation of metacognition	Metacognitive Knowledge	Specific	Researchers	8 weeks (8 x 1 hour sessions)	Suitable for primary school students and can be delivered to whole class by suitably trained teacher.	8 to 10
Metacognition-Based Reading Intervention Programs (Csíkos and Steklács 2010)	Improving knowledge about metacognition	Metacognitive Knowledge and Control	Specific	Teachers	8 weeks	Suitable for upper primary years and can be delivered to a whole class.	10 to 11
Strategy-based instruction (SBI) (Forbes and Fisher 2020)	Improving regulation of metacognition	Metacognitive Knowledge, Monitoring and Control	Specific	Teachers	8 months	Suitable for secondary students; delivered by teachers in usual classrooms. Was delivered in foreign language classes and English, but could also be done just in English classes.	13-14
Offline Metacognition (Desoete, Roeyers, and De Clercq 2003)	Improving knowledge about metacognition	Metacognitive Knowledge and Control	Specific	Trained paraprofessionals (equivalent to an SSO)	2 weeks	Suitable for students in primary school and can be implemented by SSOs.	7-9

Student Success Skills (Lemberger and Clemens 2012) (Original Record: Brigman & Campbell 2003)	Improving regulation of metacognition	Metacognitive Control	General	School counsellor led	6 months	Suitable for late primary and middle school students. Relies heavily upon the involvement of school counsellors to deliver both in-classroom and small group sessions. May be useful for students who are experiencing disaffection from school.	9-12; 12-15
conText (Lenhard et al. 2013)	Improving knowledge about metacognition	Metacognitive Knowledge	General	Teachers	8 months	Scalable computer-based program which can be used across different curriculum areas.	10-12
Thoughts in Mind Child training program (TiM-C)(Lombardi et al. 2022)	Improving regulation of metacognition	Metacognitive Knowledge	Specific	Researchers	6 weeks	Suitable for use in primary classrooms with small groups of children.	7-8
Writing Wings with Multimedia (Madden et al. 2011)	Improving knowledge about metacognition	Metacognitive Knowledge	Specific	Teachers	1 year	Suitable for teachers to deliver in primary classrooms with minimal training required (one day). Focus appears to be more on writing outcomes than on metacognitive improvements.	7-10
Metacognitive reading strategy training (Martínez and De Zarobe 2017)	Improving regulation of metacognition	Metacognitive Knowledge and Control	General	Researchers	6 months	Suitable for primary school students and contains a flexible mode of delivery in that it can be used individually, paired or with groups of students.	10-11
APLUS, APLUS TUTOR & COG TUTOR+ (Matsuda, Weng, and Wall 2020)	Improving knowledge about metacognition	Metacognitive Knowledge	Specific	Online program	4 days	A scalable program that is suited to middle-school mathematics classrooms/lessons (focuses on algebra) or could be used for SSOs working with students in mathematics-based intervention programs.	10-14
iSTART (McNamara et al. 2007)	Improving regulation of metacognition	Metacognitive Knowledge and Monitoring	General	Online program	Not specified	Suitable for students across secondary schools and is a scalable training program which focuses on supporting students' reading strategies.	12-18
Motivational Metacognitive Model	Promoting general awareness of	Metacognitive Knowledge	General	Teachers	1 school year	Delivered by teachers in usual primary school classrooms but required 100 hours of initial training.	9-10

(MM) (Frolli et al. 2021)	importance of metacognition						
Mindmapping as a meta-learning strategy (Merchie and Van Keer 2016)	Improving regulation of metacognition	Metacognitive Knowledge, Monitoring and Control	General	Researchers and teachers	10 weeks	Suitable in terms of a timeframe for schools (1 lesson per week for 10 consecutive weeks) and can be used to fit with classroom texts. Sample size would indicate that intervention is scalable.	11-12
IMPROVE (Mevarech and Amrany 2008; Mevarech and Kramarski 1997)	Improving regulation of metacognition	Metacognitive Knowledge and Control	Specific	Researchers	~1 month	Sample size indicates that it is a scalable intervention. Encourages group work and development of mathematical reasoning, however, it contains a narrow focus on algebra.	11-13
Attention Training Technique (Murray et al. 2018; Murray, Theakston, and Wells 2016)	Improving regulation of metacognition	Metacognitive Control	General	Researcher, research assistant and teachers	4 days	Not practical for a class environment as it requires one-to-one intervention. Suitable for individual students who require support in improving inhibitory control.	5-7
Metacognitive engagement (Nielsen, Nashon, and Anderson 2009)	Promoting general awareness of importance of metacognition	Metacognitive Knowledge, Monitoring and Control	Specific	Physics teacher	1 month	Suitable for senior school Physics program, but would need to determine if it fits with SACE Stage 1 and/or 2 Physics curriculum and performance standards. Difficulties for regional schools to access an amusement park or similar. Not scalable.	15-18
Metacognitive Scientific Reconstruction (Orion and Kali 2005)	Improving regulation of metacognition	Metacognitive Knowledge	Specific	Researchers and science teachers	30 hours	Suitable for middle school students in a secondary setting and sample size would indicate that intervention is scalable. Encourages scientific inquiry skills, but is domain specific.	11-13
Computer-delivered support (Pol et al. 2009)	Fostering environment that promotes metacognitive awareness	Metacognitive Knowledge and Monitoring	Specific	Researchers and web-based program	14 x 45 minutes lessons	Suitable for senior school students. A flexible program which allows students to be in control of their own learning and select the kind of help they need.	15-16

Nexxo-training (Rossignoli-Palomeque, Perez-Hernandez, and González-Marqués 2020)	Improving regulation of metacognition	Metacognitive Monitoring	General	Researchers and web-based app	5 weeks (2 x 15 minute sessions per week)	Suitable for use with junior primary school students. Scalable through use of the touchscreen app.	6-9
L1-assisted reciprocal teaching (Fung, Wilkinson, and Moore 2003)	Improving regulation of metacognition	Metacognitive Knowledge, Monitoring and Control	Specific	Researcher	4 or 5 weeks	Intervention suitable for ESL students; requires teachers fluent in students' first language as well as English.	11-13
Schema-based instruction (SBI) (Jitendra et al. 2015)	Improving knowledge about metacognition	Metacognitive Knowledge	Specific	Teachers	6 weeks	Intervention conducted by teachers, replacing usual classroom content, but only for particular/specific topics.	12-13
Metacognitive strategy and working memory training (MetaCogmed) (Jones et al. 2020)	Improving regulation of metacognition	Metacognitive Knowledge and Control	Specific	Researchers	6-7 weeks	Metacognitive component used workbooks with minimal supervision, but was not implemented separately from working memory training which used proprietary software.	9-14
Modified Solve It (Krawec and Huang 2017)	Improving regulation of metacognition	Metacognitive Knowledge and Control	Specific	Teachers	6 months	Incorporated into/replaced part of usual maths curriculum for approx half school year; conducted by teachers. But not purely metacognitive.	10-12
Metacognitive support for intelligent tutoring (Schwonke et al. 2013)	Improving regulation of metacognition	Metacognitive Knowledge and Control	Specific	Researchers	90 minutes (once)	Use of cue cards to provide metacognitive support could be added to existing computer-based maths learning programs.	13-14
Mathematical metacognitive discourse with IMPROVE (Shilo and Kramarski 2019)	Improving regulation of metacognition	Metacognitive Knowledge and Control	Specific	Teachers (with some researcher support)	4 months	Could be integrated into part of usual maths classroom teaching, but teacher training required.	10-11

Triangulating Chemistry (ETC) (Thomas 2017)	Improving regulation of metacognition	Metacognitive Knowledge, Monitoring and Control	Specific	Teacher	10 weeks	Domain specific to upper-secondary chemistry; could replace usual classroom teaching if teachers were on board and undertook training.	16-17
Metacognition and meta-affect (Tzohar-Rozen and Kramarski 2017)	Improving regulation of metacognition	Metacognitive Knowledge, Monitoring and Control	Specific	Teachers	5 weeks	Replaced usual maths problem solving classes and taught by teachers.	10-11
Feuerstein Instrumental Enrichment program (FIE) (Tzuriel et al. 2023)	Improving regulation of metacognition	Metacognitive Knowledge, Monitoring and Control	General	Teachers	1 school year	Requires extensive teacher training and replaces usual content-based classes for min 2 hours per week.	9-10
Non-instructional prosocial intervention program (Umino and Dammeyer 2016)	Improving regulation of metacognition	Metacognitive Knowledge and Control	General	Student-led, with teacher reminders	10 weeks	Could be incorporated into primary school classes with minimal class time and teacher involvement required.	11-13
Thought in Mind (TiM) teacher training (Valle et al. 2016)	Fostering environment that promotes metacognitive awareness	Metacognitive Knowledge	General	Teachers	1 school year	Techniques and activities could be incorporated into everyday primary school classroom teaching.	10
Explicit instruction of metacognition in visual arts education (van de Kamp et al. 2015)	Improving knowledge about metacognition	Metacognitive Knowledge	Specific	Teachers	one 50-minute lesson	Could be incorporated into usual visual arts curriculum at senior secondary level.	16-17

Becoming original: divergent thinking strategy instruction (van de Kamp, Admiraal, and Rijlaarsdam 2016)	Improving knowledge about metacognition	Metacognitive Knowledge	Specific	Teacher	one 50-minute lesson	Could be incorporated into usual visual arts curriculum at senior secondary level.	16-17
Writing routines (van Ockenburg, van Weijen, and Rijlaarsdam 2023)	Improving knowledge about metacognition	Metacognitive Knowledge and Control	Specific	Teacher-researchers	one lesson (metacognitive component)	Only incorporates metacognitive component into one lesson of larger writing unit/intervention.	13-14
Thinking Science cognitive acceleration intervention (Venville and Oliver 2015)	Improving regulation of metacognition	Metacognitive Knowledge and Control	Specific	Teachers	2-year classroom intervention	Suitable for middle school students with intervention designed to meet Australian Curriculum. Intervention has been trialled in an Australian school context.	12-14
Metacognitive strategies (Wagaba et al. 2016)	Improving regulation of metacognition	Metacognitive Knowledge and Control	Specific	Teacher-researcher	6 weeks (33.3 hours of curriculum time)	Suitable for a Year 9 science classroom focusing on concepts of light. Has been trialled in an Australian school context, but no significant increases in students' use of metacognitive strategies found.	14-15
Metacognitive Approach to Social Skill Training—Revised (MASST-R) (Whetstone, Gillmor, and Schuster 2015)	Improving regulation of metacognition	Metacognitive Knowledge and Control	General	Teachers	1 year	Suitable for use across secondary school year levels, however sample size limits generalisability of the findings.	14-19
Write to learn in science (Wright et al. 2019)	Improving regulation of metacognition	Metacognitive Knowledge and Control	Specific	Teachers (with some researcher support)	8 weeks	Suitable for use across secondary school year levels in science classrooms, however sample size limits generalisability of the findings.	10-17

Direct instruction of metacognition (Zepeda et al. 2015)	Improving regulation of metacognition	Metacognitive Knowledge, Monitoring and Control	Specific	Teachers	30 weeks	Suitable for a Year 8 science classroom, but adjustments would need to be made to ensure content fits with Australian Curriculum.	12-14
Transfer plus SRL (Fuchs et al. 2003)	Improving regulation of metacognition	Metacognitive Knowledge and Monitoring	Specific	Teachers and researchers	16 weeks	Implemented by teachers in usual classrooms; general maths problem solving that could potentially adapted to Australian curriculum.	8-9
Thinking your problems away (Collingwood)	Improving regulation of metacognition	Metacognitive Knowledge, Monitoring and Control	Specific	Teaching assistants	4 weeks	The components added to IMPROVE intervention would take extra time but did not improve outcomes.	7-8
SRL and calibration (Digiacomo and Chen 2016)	Improving regulation of metacognition	Metacognitive Knowledge and Monitoring	Specific	Teachers	3 week	Not practically scalable as conducted in very small groups outside of timetabled maths class time (eg in art, club, etc periods).	11-13
E-learning with IMPROVE (Kramarski and Gutman 2006)	Improving regulation of metacognition	Metacognitive Knowledge	Specific	Teachers	5 weeks	Could potentially be implemented in usual maths curriculum; practical where e-learning already used.	14-15
Online discussion with IMPROVE (Kramarski and Mizrachi 2006)	Improving regulation of metacognition	Metacognitive Knowledge	Specific	Teachers	4 weeks	Use of online discussion forums to support IMPROVE metacognitive intervention could be readily implemented, if appropriate monitoring/ moderation available.	13-14
IMPROVE versus WWWH (Kramarski, Weiss, and Sharon)	Improving regulation of metacognition	Metacognitive Knowledge and Control	Specific	Teachers	3 weeks	Both interventions considered use prompt cards to support application of metacognitive processes in usual maths curriculum, with minimal teacher training required.	13-14
SRL training (Leidinger and Perels 2012)	Improving regulation of metacognition	Metacognitive Knowledge	General	Teachers	6 weeks	General metacognitive strategy instruction implemented in place of one usual math lesson per week, but quite specific age-group wise.	8-9
Self-regulation for threshold learning (Maloney, Ryan, and Ryan 2021)	Improving knowledge about metacognition	Metacognitive Knowledge and Monitoring	General	Researchers	10 weeks	General metacognitive strategy instruction applied to mathematics, but time and resource intensive (not usual classes, conducted by researchers, 2-3 hour sessions).	14-16

SRL mentoring (Núñez et al. 2013)	Improving regulation of metacognition	Metacognitive Knowledge, Monitoring and Control	General	Teachers	1 school year	Small group mentoring after school not practical at large scale.	12-13
SRL and maths strategy training (Otto and Kistner 2017)	Improving regulation of metacognition	Metacognitive Knowledge, Monitoring and Control	General	Researchers	7 weeks	Not implemented by teachers, but was aligned with existing curriculum.	8-9
Homework-focused SRL training (Stoeger and Ziegler 2010)	Improving knowledge about metacognition	Metacognitive Monitoring and Control	General	Teachers	5 weeks	Training implemented by teachers in usual classrooms but requires impractical amount of homework for Australian primary school context.	10-11

Table 2: Intervention list: reliability and validity

Name of Intervention	Results	Recommendation on the basis of the quality of the science	Sample size	Sample context/setting	Evidence Hierarchy
Meta-CIC (Collaborating Inquiry Community) (Adler, Zion, and Mevarech 2016)	No positive impact. Results inconclusive. Sample too small.	Not recommended	250	Schools, Israel	Level 2: At least one RCT
Mental Contrasting with Implementation Intentions (MCII) (Duckworth et al. 2013)	Moderate positive effects, although the RCT was underpowered and sample characteristics varied at baseline.	Conditional	77	Low socio-economic school, USA	Level 2: At least one RCT
Training executive processes of working memory (WM) (Elosúa et al. 2013)	Unable to interpret results. No quantitative results documented/provided.	Not recommended	40	School, Spain	Unable to rate
AstroWorld (Arvidsson and Kuhn 2021)	Basic descriptive analyses presented - difficult to interpret from a quantitative point of view, e.g. no baseline comparative data presented and the sample was small. Data favoured the teacher involved intervention condition over the computer program only.	Not recommended	72	School, US	Level 3: Quasi Experimental - control group but not randomised
Training Program (Bianco et al. 2021)	Theory of Mind programs positively impacted metacognitive knowledge.	Recommended	91	Public schools, Northern Italy	Level 2: At least one RCT
Learner's Toolkit (Byers et al. 2022)	Difficult to interpret any results	Not recommended	207	Secondary schools, Australia	Level 6: Descriptive analyses
Metacognitive monitoring and control (Dörr and Perels 2019)	The sample was small considering 4 treatment arms and one control arm. Indicated that the combined training of parents and teachers led to improved child level results.	Conditional	137	German kindergartens	Level 3: Quasi Experimental - control group but not randomised

Training Activities (Cornoldi et al. 2015)	Small to moderate effects were found for metacognition and working memory, plus evidence of transfer effects on math problem solving.	Conditional	135	Primary schools, Northern Italy	Level 3: Quasi Experimental - control group but not randomised
Metacognition-Based Reading Intervention Programs (Csíkos and Steklács 2010)	Small to moderate effects were found for reading and comprehension after metacognitive strategy classes.	Recommended	244	Schools in low SES contexts, Hungary	Level 2: At least one RCT
Strategy-based instruction (SBI) (Forbes and Fisher 2020)	Small sample, results were weak but positive, however difficult to interpret.	Conditional	45	Secondary school, England	Level 3: Quasi Experimental - control group but not randomised
Offline Metacognition (Desoete, Roeyers, and De Clercq 2003)	Children in the metacognitive program achieved significant gains in trained metacognitive skills compared with the 4 other conditions.	Recommended	237	Schools, Belgium	Level 2: At least one RCT
Student Success Skills (Lemberger and Clemens 2012)	Students reported significant changes in metacognitive skill and feelings of connectedness to school and received higher posttest change scores on certain executive functioning subscale items.	Recommended	180	Schools, USA	Level 2: At least one RCT
conText (Lenhard et al. 2013)	Study compared two treatment groups, but no control group comparison. Results suggest that guided practice (characterised by intensive practice and individualised corrective feedback), is superior to explicitly teaching strategy knowledge.	Conditional	148	Schools, Germany	Level 6: Descriptive analyses
Thoughts in Mind Child training program (TiM-C)(Lombardi et al. 2022)	Results suggest that it is possible to enhance mentalization by promoting the understanding of the relations between mind and emotion and teaching metacognitive skills.	Recommended	56	Schools, Italy	Level 2: At least one RCT
Writing Wings with Multimedia (Madden et al. 2011)	The WWM had moderate effects on overall writing, writing style and writing mechanics and no effect on ideas and organisation - however after adjusting for class level clustering these results were not significant.	Not recommended	922	Schools, USA	Level 2: At least one RCT
Metacognitive reading strategy training (Martínez and De Zarobe 2017)	Results indicated that a metacognitive reading strategy intervention centred in reading could benefit both Content and Language Integrated Learning and English as a Foreign Language in comparison to a control conditions.	Recommended	145	Schools, Spain	Level 2: At least one RCT

APLUS, APLUS TUTOR & COG TUTOR+ (Matsuda, Weng, and Wall 2020)	Compared 4 groups - 3 learning by teaching interventions and a control group. All 3 interventions had a small impact with little difference between the three.	Not recommended	208	Schools, USA	Level 2: At least one RCT
iSTART (McNamara et al. 2007)	Intervention has a positive impact on student's comprehension - although the magnitude of effects not reported. Seems to have greater impact on less skilled students.	Conditional	Not specified	Not specified	Level 2: At least one RCT
Motivational Metacognitive Model (MM) (Frolli et al. 2021)	Two treatment groups compared to each other with no control group. Impossible to interpret results.	Not recommended	88	low SES students in Italian primary schools	Level 6: Descriptive analyses
Mindmapping as a meta-learning strategy (Merchie and Van Keer 2016)	Mind maps supported students' cognitive and metacognitive text-learning strategies and free recall performance over the control condition. Effect sizes not calculated.	Conditional	644	Schools, Belgium	Level 3: Quasi Experimental - control group but not randomised
IMPROVE (Mevarech and Amrany 2008; Mevarech and Kramarski 1997)	Large positive effect sizes despite small sample and uneven balance at baseline.	Conditional	247	Schools, Israel	Level 2: At least one RCT
Attention Training Technique (Murray et al. 2018; Murray, Theakston, and Wells 2016)	Well designed and analysed study. Attention Training Technique (ATT) improved young children's ability to delay gratification as well as verbal inhibition.	Recommended	100	Schools, England	Level 2: At least one RCT
Metacognitive engagement (Nielsen, Nashon, and Anderson 2009)	Qualitative evaluation only.	Not recommended	14	Secondary schools, Canada	Level 6: Descriptive analyses
Metacognitive Scientific Reconstruction (Orion and Kali 2005)	Results difficult to decipher - data not analysed correctly - details not provided to be able to interpret with confidence.	Not recommended	582	Schools, Israel	Level 6: Descriptive analyses

Computer-delivered support (Pol et al. 2009)	Students working with the most elaborate instruction scheme showed an increased use of their pallet of heuristics and algorithms. Furthermore, the instruction scheme in which hints were available to students during problem-solving proved to be most effective when students showed an increase in the systematic use of hints during problem-solving. Small sample when split into two experimental groups and a control. Effect sizes not calculated.	Conditional	59	Secondary schools, Netherlands	Level 2: At least one RCT
Nexxo-training (Rossignoli-Palomeque, Perez-Hernandez, and González-Marqués 2020)	Well-designed study. The 3rd grade experimental group displayed a significant reduction in attentional problems at follow-up compared to both control groups. Executive Function problems were also reduced at follow-up in the experimental group. Participants in this group improved in Supervision (self-monitoring) at post-intervention and follow-up compared to passive-controls. Effect sizes not calculated.	Recommended	108	Primary schools, Spain	Level 2: At least one RCT
L1-assisted reciprocal teaching (Fung, Wilkinson, and Moore 2003)	No control condition. Very small sample. Unable to interpret results.	Not recommended	12	ESL students in NZ secondary schools	Level 6: Descriptive analyses
Schema-based instruction (SBI) (Jitendra et al. 2015)	Well-designed study. Good sample. Very large effects were found for the SBI at post-test and retention test (9 weeks later) and also showed significantly more growth in proportional problem solving. There were no treatment effects on the Process and Applications subtest of the Group Mathematics Assessment and Diagnostic Evaluation.	Recommended	1981	US secondary schools	Level 2: At least one RCT
Metacognitive strategy and working memory training (MetaCogmed) (Jones et al. 2020)	Well designed and described study. Working memory training improved working memory and mathematical reasoning relative to the control group. The improvements in working memory were maintained 3 months later, and these were significantly greater for the group that received metacognitive strategy training, compared to working memory training alone. Effect sizes not calculated.	Recommended	95 (77 completed program)	English secondary schools (and one primary)	Level 2: At least one RCT

Modified Solve It (Krawec and Huang 2017)	Though CBM scores in the intervention group were initially lower than that of the comparison group, intervention students improved significantly more in the first phase, with no differences in the second phase. Overall minimal effects.	Not recommended	307	US schools (grade 5-6)	Level 3: Quasi Experimental - control group but not randomised
Metacognitive support for intelligent tutoring (Schwonke et al. 2013)	Metacognitive support (1) reduced the total learning time (main effect), and for low-prior knowledge students especially, the time they spent inspecting available help facilities and external representations of the subject matter (ATIeffect) (2) increased learning efficiency. However learning success was only found for those who already had metacognitive knowledge. Magnitude of effects difficult to interpret - effect sizes not provided.	Conditional	60	German high school	Level 2: At least one RCT
Mathematical metacognitive discourse with IMPROVE (Shilo and Kramarski 2019)	Comparison of two interventions - no pure control group. The findings indicated that the experimental group (IMPROVE) exhibited more conceptual verbalization related to planning and reflection processes, whereas the control group (mathematical discourse question prompts and student sensemaking in a problem-solving test performance) scored the highest with regard to procedural knowledge. As a transfer measure from the intervention program at the end of the study, students in the experimental group outperformed the control group in terms of problem-solving and sensemaking performance. Results difficult to interpret as no proper control.	Not recommended	824	Primary schools, Israel	Level 6: Descriptive analyses
Triangulating Chemistry (ETC) (Thomas 2017)	Primarily qualitative reflections. Not able to determine any impact on students outcomes from this paper.	Not recommended	27	High school, Canada	Level 6: Descriptive analyses
Metacognition and meta-affect (Tzohar-Rozen and Kramarski 2017)	Mixed methods indicated that students who participated in the metacognitive and meta-affective intervention programs presented similar but higher achievements than the control group. Small sample when split into the three groups. Effect sizes not provided but results were strong especially considering the sample size.	Conditional	170	Middle schools, Israel	Level 2: At least one RCT
Feuerstein Instrumental Enrichment program (FIE) (Tzuriel et al. 2023)	Students receiving the FIE improved their grades from pre- to post-intervention compared with the comparison group. Further, students who started the year with lower cognitive scores benefited more. Effect sizes not provided.	Conditional	131	Arab-Israeli middle school.	Level 3: Quasi Experimental - control group but not randomised

Non-instructional prosocial intervention program (Umino and Dammeyer 2016)	No changes on metacognitive skills were found.	Not recommended	45	Danish primary schools	Level 6: Descriptive analyses
Thought in Mind (TiM) teacher training (Valle et al. 2016)	One class randomised to control, one to intervention - so only one teacher trained in the program. Not able to recommend on the basis of this paper, however there are other more powered studies evaluating TiM.	Not recommended	46	Italian primary schools	Level 2: At least one RCT
Explicit instruction of metacognition in visual arts education (van de Kamp et al. 2015)	Explicit instruction of meta-cognitive knowledge had a positive effect on fluency and flexibility, but not on originality. Moderate to strong effect sizes.	Recommended	147	Upper secondary visual arts classes, Netherlands	Level 3: Quasi Experimental - control group but not randomised
Becoming original: divergent thinking strategy instruction (van de Kamp, Admiraal, and Rijlaarsdam 2016)	Control condition was not a pure control - as such the study compared the impact of two interventions. Results imply that instructional support in building up knowledge about creative generation strategies may improve students' creative processes in visual arts education. Results difficult to interpret as no control.	Conditional	219	Upper secondary visual arts classes, Netherlands	Level 5: Non-experimental pre-post
Writing routines (van Ockenburg, van Weijen, and Rijlaarsdam 2023)	Results indicated that strategy instruction is an effective approach for improving students' writing synthesis.	Conditional	233	Secondary schools, Netherlands	Level 3: Quasi Experimental - control group but not randomised
Thinking Science cognitive acceleration intervention (Venville and Oliver 2015)	The authors concluded that Thinking Science was a worthwhile intervention for all students, but particularly for students in the academically selective school where teachers were able to adapt their pedagogy and the approach to suit their students. Large effects against the control group. Baseline differences were large - difficult to interpret results.	Conditional	582	Secondary schools, Australia	Level 3: Quasi Experimental - control group but not randomised
Metacognitive strategies (Wagaba et al. 2016)	Mixed methods. Small sample. Results inconclusive.	Not recommended	35	Secondary school, Australia	Level 5: Non-experimental pre-post

Metacognitive Approach to Social Skill Training— Revised (MASST-R) (Whetstone, Gillmor, and Schuster 2015)	Very small sample. Cannot make a recommendation on the basis of this study.	Not recommended	10	Secondary school, US	Level 6: Descriptive analyses
Write to learn in science (Wright et al. 2019)	No comparison group. Completely underpowered for the analyses conducted.	Not recommended	54	Secondary school, US	Level 6: Descriptive analyses
Direct instruction of metacognition (Zepeda et al. 2015)	Essentially two classes randomised. Cannot recommend on the basis of this sample, however results revealed large effects on reduced bias when making metacognitive judgments, higher levels of motivation after instruction, performed better on a conceptual physics test, and performed better on a novel self-guided learning activity.	Conditional	46	Secondary school, US (Physics classroom)	Level 2: At least one RCT
Transfer plus SRL (Fuchs et al. 2003)	Follow-up trial comparing an already evidenced program (problem solving transfer instruction) with this plus SRL. Large effects were found for impact on self-regulated processes and problem-solving tests.	Recommended	395	Primary schools, Netherlands	Level 2: At least one RCT
Thinking your problems away (Collingwood)	Study showed a difference in maths performance and in the strategizing and focusing sub-behaviours of self-regulation. No significant differences in maths anxiety and self-concept were established, although exploratory investigation identified a significant impact on males' maths self-concept.	Recommended	144	Primary schools, England	Level 2: At least one RCT
SRL and calibration (Digiacomo and Chen 2016)	Very small sample. Cannot recommend on the basis of this study. Participants who received the intervention had significantly higher math performance and predictive/postdictive calibration accuracy than did the control group.	Not recommended	30	Private middle school, USA	Level 2: At least one RCT
E-learning with IMPROVE (Kramarski and Gutman 2006)	This study compared one class with E-learning supported with IMPROVE self-metacognitive questioning against one class with E-learning without explicit support of self-regulation. Results indicated the IMPROVE group had better problem-solving procedural and transfer tasks regarding mathematical explanations and enhanced self-monitoring strategies during problem solving.	Not recommended	65	Junior high school, Israel	

Online discussion with IMPROVE (Kramarski and Mizrachi 2006)	The study compared 4 different instructional methods in 4 separate classes: online discussion embedded within metacognitive guidance (Online+Meta), online discussion without metacognitive guidance (Online), face-to-face discussion with metacognitive guidance (Ftf+Meta), and face-to-face discussion without metacognitive guidance (Ftf). Results indicated that the Online+Meta students outperformed the other groups. Small sample, only one class per group. No control group. Cannot recommend on the basis of this study.	Not recommended	86	Junior high school, Israel	
IMPROVE versus WWWH (Kramarski, Weiss, and Sharon)	Study compared IMPROVE to what, when, why, and how (WWWH) question prompts. Simply a comparison between the two intervention groups with no control group. Findings indicated no difference between the two approaches regarding short-term effects on algebraic procedural tasks; however, differential effects emerged between the two approaches on the self-regulation measure and on long term transfer to novel tasks.	Not recommended	61	Junior high school, Israel	Level 2: At least one RCT
SRL training (Leidinger and Perels 2012)	Results indicated that students in the intervention group maintained their level of self-reported self-regulated learning activities from pre- to post-test, whereas a decline was observed for the control students. Regarding students' mathematical achievement, a slight improvement was found.	Conditional	135	Primary schools, Germany	Level 3: Quasi Experimental - control group but not randomised
Self-regulation for threshold learning (Maloney, Ryan, and Ryan 2021)	The intervention group experienced an increase in self-regulation after the intervention. Quasi-experimental although baseline data indicated equivalence. Effect sizes were not provided.	Conditional	104	Secondary schools, Ireland	Level 3: Quasi Experimental - control group but not randomised
SRL mentoring (Núñez et al. 2013)	2 classes randomly assigned to treatment or control and followed up for 9 months. Baseline data did not show equivalence. Effects were negligible for academic outcomes and moderate to strong for self-regulated learning strategies.	Not recommended	94	Middle schools, Portugal	Level 2: At least one RCT

SRL and maths strategy training (Otto and Kistner 2017)	Impacts were found for high achievers at baseline, not for low achievers. High-achievers seemed to have larger changes in their intrinsic motivation before and during learning as well as in their self-efficacy.	Not recommended	89	Primary schools, Germany	Level 4: Non-experimental longitudinal cohort, causal modelling of observational data, time series
Homework-focused SRL training (Stoeger and Ziegler 2010)	Baseline data was not equivalent and not appropriately controlled for in the data analyses. Results indicated that the intervention had a positive impact for gifted students, but not for others.	Not recommended	201	Primary schools, Germany	Level 2: At least one RCT

Summary of findings

In this section we provide details of our overall considerations of the interventions that we reviewed. We consider both methodological aspects as well as aspects of the interventions themselves.

Research design

Overall, the quality of the research designs were highly variable and of mixed quality. It was unfortunate that many of the evaluations classified as RCTs lacked quality. For example, many studies simply compared one class to another ignoring the impact of clustering at the class level. Other studies may have had multiple classes randomised but did not take account of clustering in their analyses. Class clustering is of paramount importance in school-based RCTs as it helps ensure the accuracy and generalisability of the study findings. In the school setting, students are often organised into classes or groups, and interventions are typically applied at this level. Failure to account for class clustering can lead to biased results, as students within the same class may share similar characteristics or be influenced by the same contextual factors. Studies that do not take into account clustering are also generally underpowered. By recognising and appropriately addressing class clustering, researchers can better control for the potential interdependence of data points within classes. This approach not only enhances the internal validity of the RCT but also facilitates a more precise understanding of the intervention's true effects, making the findings more reliable for policymakers and educators when considering the adoption and implementation of educational interventions in real-world classroom settings.

Another common issue found was the lack of a pure control group, with study authors opting instead to compare one intervention to another. Although you may be able to determine if one intervention is better than another, without a control group, you have no basis for comparison. You cannot determine whether the observed changes in the intervention groups are due to the interventions themselves or other confounding factors. As such, it becomes difficult to attribute any observed effects solely to the interventions being tested. Factors like student motivation, teacher quality, or external events can all influence outcomes, and without a control group, it is hard to isolate the intervention's impact. The presence of a control group also helps account for placebo and Hawthorne effects, where participants may change their behaviour simply because they are being observed or receiving attention. Without a control condition, you cannot differentiate between such effects and the genuine impact of the interventions.

Sample sizes

The sample sizes in the included studies varied broadly, ranging from as few as 10 students to as many as 1,981 students (Mean = 209; SD = 308). Most of these studies (64%) featured sample sizes of less than 150 students, while 20% had samples of fewer than 50 students. A minority of the studies (10%) included sample sizes exceeding 500 students.

There are limitations posed by the wide variability in sample sizes across the included studies. With some studies involving as few as 10 students, raises concerns about the generalisability of the findings. Studies with small sample sizes may not accurately represent the broader population, making it challenging to draw strong, reliable conclusions based solely on these results (Elosúa et al. 2013; Forbes and Fisher 2020; Whetstone, Gillmor, and Schuster 2015). It is also important to note that large sample sizes did not necessarily lead to positively significant outcomes (e.g., (Madden et al. 2011)).

Common bad practice found when analysing results

Rather than simply comparing the differences between the intervention and control group at the end of the intervention or study follow-up period, many authors compared the difference between the pre and post-tests. Comparing pre and post-tests within the same group in a RCT is considered bad practice when evaluating the impact of an intervention because it can lead to flawed conclusions and lacks the rigor needed for robust causal inference. Without a control group, comparing pre and post-tests within the same group cannot account for potential confounding factors and alternative explanations for observed changes. It is also common for individuals or groups to experience fluctuations in performance or outcomes over time due to random variation. When comparing pre and post-tests within the same group, you may observe improvements or declines simply because of this natural regression to the mean, rather than due to the intervention's impact.

Most important, in a RCT, random assignment of participants to intervention and control groups is done to ensure that these groups are comparable at the outset. Comparing pre and post-tests within a single group does not account for this randomisation, potentially introducing selection bias, as participants who receive the intervention may differ systematically from those who do not. RCTs are designed to establish causal relationships between interventions and outcomes. By comparing the difference at the end between the intervention and control groups, you can more confidently attribute any observed effects to the intervention itself, rather than other factors.

Types of metacognitive intervention

Previous meta-analyses on metacognitive interventions, like the studies by Dignath et al. (Dignath and Büttner 2008; Dignath, Büttner, and Langfeldt 2008), have highlighted the significant impact of teaching metacognitive strategies and their benefits on primary and secondary school achievement. Additionally, the monitoring processes essential to metacognitive regulation play a crucial role in effective self-regulated learning (Dignath et al. 2023). Given this, it is logical that the central emphasis of the interventions detailed in the articles centred on improving the regulative metacognitive processes which students use in their learning. While this was not always overtly conveyed to the participants, researchers often emphasised how better regulation could positively influence other areas, such as academic performance. At times, the context was specific, yet studies often identified broader outcomes when there was a strong metacognitive component. This is evident in Mevarech and Kramarski's 'IMPROVE' approach, as well as its modified version by Shilo and Kramarski (2018) titled 'Mathematical Metacognitive Discourse with IMPROVE', where students employed metacognitive questioning to strategically guide their learning by monitoring and managing their thinking.

Several studies, including Jitendra et al. (2015), primarily instructed learners on metacognitive knowledge, with less emphasis on monitoring and control processes. While these studies delved into the effects of explicit learning strategy instruction on students, they didn't investigate the timing or application of these strategies.

The interventions least frequently coded pertained to promoting general awareness of metacognition or crafting environments conducive to metacognitive growth. While this indirect approach is pivotal in nurturing self-regulated learners (Dignath and Veenman 2021), many direct interventions spanned an extended duration (ranging from 16 days to a year), allowing sufficient time to create a metacognition-supportive environment.

Aspects of metacognitive impact

Most studies highlight enhanced metacognitive knowledge as a sign of success, whilst often concurrently exploring monitoring and control elements. Given that many quantitative metacognitive measures source participant knowledge, this finding is expected. However, there is a distinct acknowledgment that all metacognitive elements are crucial, particularly when prompting students to utilise their metacognitive resources. This was often achieved in studies through triangulating data to show improvement in the participants’ metacognitive processes as they undertook tasks.

Monitoring processes, while sometimes addressed, were less emphasised, likely due to the challenges of in situ measurement. Within the studies, mentions of monitoring and control often surfaced in questionnaires focused on related items, rather than assessing the actual processes. This suggests that these could alternatively be coded as an exploration of metacognitive knowledge about these strategies, rather than their direct application. Additionally, it should be noted that there was quite a lot of overlap between cognitive monitoring, as would be seen in judgements of learning, and metacognitive monitoring processes such as wider considerations of the learning process. This ambiguity also affects elements categorised as metacognitive control, detailing how metacognitive knowledge and feedback from metacognitive monitoring steer the enhancement of learning processes.

Developmental level

The majority of reported interventions were carried out in primary school settings (53%), with 40% implemented in secondary schools, and 7% spanning both primary and secondary levels.

The developmental trajectory of metacognition spans from early childhood through adolescence and beyond. Studies by Whitebread and colleagues (Bryce and Whitebread 2012; Whitebread et al. 2007; Whitebread et al. 2009) have challenged the notion that metacognition is a late-developing skill, emphasising that metacognitive thinking emerges substantially in early years. Metacognitive development is a gradual, multidimensional competence, with different components evolving at various stages (Kuhn 2000). Cognitive monitoring appears to begin early and progress steadily with age. In contrast, cognitive control, shaped by environmental and social factors, exhibits individual variations among young children. Empirical evidence suggests that young children engage in self-regulation activities (Dignath, Büttner, and Langfeldt 2008), and even the youngest children benefit from training (Hattie, Biggs, and Purdie 1996). In fact, Hattie, Biggs, and Purdie (1996) suggest that working with young children can be effective because they haven't developed unhelpful learning habits yet, making it easier to teach them positive learning behaviours. With younger children (kindergarten), indirect interventions which focus on caregivers, parents or teachers, may be more beneficial than direct interventions as shown in Dörr and Perels (2019). In this type of intervention, the emphasis is placed on observational learning or modelling. This involves adults exhibiting positive instances of learning behaviour, which children then observe and mimic.

The trajectory of metacognition continues through primary and secondary schooling, reflecting distinct developmental milestones. Primary school students transition from identifying and describing thinking and learning strategies to reflecting on and adjusting these strategies. Most of the interventions focusing on metacognitive knowledge in primary years led to significant improvements (Bianco et al. 2021; Cornoldi et al. 2015; Lombardi et al. 2022; Valle et al. 2016). Lenhard et al. (2013) showed that their intervention improved Year 6 students improved their strategy knowledge and reading comprehension through guided practice and individualised corrective feedback, an approach shown to be more effective than explicitly teaching strategy knowledge. However, programs such as Writing Wings (Madden et al. 2011), which focused on metacognitive knowledge in Years 3 and 4 in America, produced mixed findings. While hierarchical linear modelling indicated that the program had no impact, an analysis of covariance revealed slight positive effects on certain outcomes. Consequently, the overall results of this study remain inconclusive.

The interventions focusing on metacognitive control in primary years yielded conflicting results. While some studies, like those by Elosua et al. (2013) and Duckworth et al. (2018), lacked sufficient statistical power and did not demonstrate significant effects, others, such as the research conducted by Lemberger and Clemens (2011), showed notable improvements, with students reporting significant positive changes in their metacognitive skills. Some studies focused on both metacognitive knowledge and metacognitive control in primary years and showed significant improvements in terms of students' metacognition, their overall quality of life (Umino and Dammeyer 2016) and their academic achievement in reading and mathematics (Csíkos and Steklács 2010; Desoete, Roeyers, and De Clercq 2003; Mevarech and Amrany 2008).

Secondary school students can incorporate alternative perspectives and opposing viewpoints into their metacognitive thinking, ultimately becoming independent learners capable of planning, organising, setting goals, evaluating, monitoring, revising and understanding the 'why' behind their strategies. Notably, metacognitive development is not solely age-dependent; it depends on opportunities for practice and experience (Schneider and Lockl 2002).

Many of the studies where the metacognition intervention took place in secondary school had no significant impact or weak effects because they were either underpowered, used questionable data analysis methods or did not include quantitative evaluations (Adler, Zion, and Mevarech 2016; Arvidsson and Kuhn 2021; Digiacomo and Chen 2016; Forbes and Fisher 2020; Nielsen, Nashon, and Anderson 2009; Orion and Kali 2005; Pol et al. 2009; Wagaba et al. 2016; Whetstone, Gillmor, and Schuster 2015; Wright et al. 2019) or because the metacognitive component of the intervention only took place over the course of a single lesson (van de Kamp, Admiraal, and Rijlaarsdam 2016; van de Kamp et al. 2015; van Ockenburg, van Weijen, and Rijlaarsdam 2023). Interestingly, some studies conducted in secondary years showed divergent results among various groups of students, with some demonstrating amplified effects in less skilled students (McNamara et al. 2007) and others revealing learning success exclusively among students equipped with pre-existing metacognitive knowledge (Schwonke et al. 2013).

Domain specificity

Our data showed that metacognition interventions were more frequently applied in the context of specific disciplines (66% of the studies) than in general contexts such as improving students' social and behavioural skills (34% of the studies). This means that the majority of the interventions were designed to target metacognitive skills within particular subject areas or domains, such as mathematics, or science, rather than aiming for broader, cross-domain metacognitive development. Notably, within subject-specific interventions, mathematics emerged as the most frequently examined discipline with 45% of the included records, followed by science at 25%, reading and writing at 20%, with arts and second language studies making up 5% each of the studies reviewed.

Some studies also focused on Theory of Mind as a specific domain. The results of these studies indicate that enhancing mentalisation is achievable through the promotion of understanding the connections between the mind and emotions, along with the instruction of metacognitive skills (Bianco et al. 2021; Lombardi et al. 2022). The impact of Theory of Mind programs on metacognitive knowledge appears to be largely positive in primary school settings. However, when extending these findings to secondary education, the conclusions become less definitive, primarily because of the small sample sizes used (Valle et al. 2016).

This emphasis on domain-specific interventions may reflect a recognition of the unique cognitive demands posed by different subjects and the need for tailored strategies to enhance metacognition effectively within those specific academic contexts. However, it also raises questions about the potential benefits of fostering more generalised metacognitive skills that could be applied across diverse learning situations. Theories suggest that metacognitive knowledge abilities tend to start as highly specific to particular domains but progressively become more versatile across domains as individuals accumulate knowledge and experience (Borkowski, Chan, and Muthukrishna 2000), with metacognitive control exhibiting a similar developmental pattern (Weil et al. 2013). The evolving nature of metacognitive knowledge and control abilities, transitioning from domain-dependent to domain-general, suggests that metacognition interventions should be developmentally tailored. Interventions could initially emphasise domain-specific strategies, aligning with students' cognitive readiness, and gradually introduce domain-general metacognitive skills as learners mature. To promote the natural progression of metacognition, educators could encourage interdisciplinary connections and recognise that metacognitive development is a long-term educational journey.

Duration of the intervention

The intervention durations varied widely, ranging from a single 50-minute lesson to two full school years, with the most common durations being 4 to 8 weeks (39%), followed by 3 to 12 months (21%), 1 to 2 years (16%), 1 to 3 weeks (13%), and single lessons (7%), while a minority of studies (4%) did not specify their intervention duration. In their meta-analysis of SRL and metacognition intervention in primary years, Dignath et al. (2008) did not find intervention length to be a significant potential moderator for intervention effectiveness, except for students' performance in categories other than maths and reading/writing, where effect sizes increased with shorter durations, although this trend did not generalise to other outcome categories. However, these findings differ from the results of Dignath and Büttner's later meta-analysis (Dignath and Büttner 2008) on self-regulated learning interventions in primary and secondary years. They found that longer interventions were more effective, highlighting the development of more automated and sophisticated strategy use with experience. To facilitate the transfer of metacognitive knowledge and strategy adoption into students' learning behaviour, they recommend that interventions should span a longer duration, allowing for intensive acquisition and practice of self-regulated learning strategies.

The optimal duration for metacognition interventions in schools varies based on specific objectives and contextual factors. Short-term interventions, such as single lessons or a few weeks, can be effective for introducing basic metacognitive concepts (Desoete, Roeyers, and De Clercq 2003; van de Kamp, Admiraal, and Rijlaarsdam 2016; van de Kamp et al. 2015), while medium-term interventions (spanning a few months) are suitable for in-depth skill development (Forbes and Fisher 2020). Long-term interventions, lasting one to two years, are typically used for comprehensive metacognitive development, especially for domain-general skills (Frolli et al. 2021; Tzuriel et al. 2023; Valle et al. 2016; Whetstone, Gillmor, and Schuster 2015). The choice of duration should align with intervention goals, students' needs, and the complexity of metacognitive skills and strategies.

Implementation of the intervention

The implementation of the interventions in this review was conducted by teachers (48%), researchers (27%), teachers in collaboration with researchers (14%), an online programme (6%), or an SSO or school counsellor (5%). With the majority of these interventions delivered by teachers, their effectiveness might be influenced by teachers' attitudes and training (Dignath, Büttner, and Langfeldt 2008). While the development of metacognition is impacted by both age and the learning environment, teachers play a crucial role in shaping this environment (Chung 2000). However, many teachers have limited familiarity with strategic learning and metacognitive concepts and may not prioritise their instruction (Waeytens, Lens, and Vandenberghe 2002). There is a risk that some teachers may lack the necessary training or resources to implement interventions optimally, potentially leading to inconsistent or less effective results.

Researchers typically bring a deep understanding of metacognition and can design and implement interventions based on current scientific knowledge. This can result in well-structured and evidence-based interventions. Previous meta-analyses have shown that researcher-led interventions were more efficient compared to teacher-directed ones (Dignath, Büttner, and Langfeldt 2008; Hattie, Biggs, and Purdie 1996). However, researchers' interventions may sometimes be less integrated into the everyday classroom experience and may require additional time and resources for implementation. There is also a risk of a "researcher-teacher gap," where interventions designed by researchers may not align perfectly with the practical constraints and needs of teachers and students (Boekaerts and Corno 2005).

It is therefore reasonable to assume potential differences in the effectiveness of teacher-directed versus researcher-directed training, as researchers may emphasise the importance of self-regulated learning (Hattie, Biggs, and Purdie 1996), but teachers can integrate strategy instruction into their regular teaching, helping students in transferring strategies to various academic contexts. It is worth noting that the quality and intensity of teacher preparation were not extensively reported in the included studies.

Ultimately, collaborations between researchers and teachers can often lead to the most effective metacognition interventions (Merchie and Van Keer 2016; Murray et al. 2018; Murray, Theakston, and Wells 2016; Orion and Kali 2005), as they combine theoretical knowledge with practical application, ensuring that interventions are both grounded in research and tailored to the needs of students and educators (Dignath and Büttner 2018; Stanton, Sebesta, and Dunlosky 2021).

Recommendations

Of the 56 interventions that we reviewed, we can only recommend 7 for deeper consideration on the basis of the quality of the theoretical underpinning of the program, the practical aspects, and the quality of the science behind determining the impact on student outcomes. The seven are:

- ***Theory of Mind Training Program*** (Bianco et al. 2021). This study compared two different Theory of Mind training programs to a control condition. Both programs showed to positively impact metacognitive knowledge.

- ***Metacognition-Based Reading Intervention Program*** (Csíkos and Steklács 2010). This program showed small to moderate effects for both reading and comprehension outcomes after their metacognitive strategy classes.
- ***Offline Metacognition*** (Desoete, Roeyers, and De Clercq 2003). This study compared multiple interventions, evidencing that children in the metacognitive program achieved significant gains in trained metacognitive skills compared with the other conditions.
- ***Student Success Skills*** (Lemberger and Clemens 2012). Multiple studies support this intervention, with outcomes showing that students self-reported positive changes in metacognitive skill and feelings of connectedness to school and received higher post-test change scores on certain executive functioning subscale items.
- ***Thoughts in Mind - Child*** training program (TiM-C) (Lombardi et al. 2022). This is another program with multiple studies evidencing its impact. Their results suggest that it is possible to enhance mentalisation by promoting the understanding of the relations between mind and emotion and teaching metacognitive skills.
- ***Metacognitive reading strategy training*** (Martínez and De Zarobe 2017). This was one of the few studies that evidenced positive impact on academic outcomes with an element of transfer. Here, results indicated that the intervention centred in reading could benefit both Content and Language Integrated Learning and English as a Foreign Language in comparison to a control conditions.
- ***Attention Training Technique*** (Murray et al. 2018; Murray, Theakston, and Wells 2016). This is another program where there were multiple papers evidencing positive impact. Further these studies were well designed and analysed, providing greater confidence in the results. Overall, the intervention, showed to improve children's ability to delay gratification as well as positively influence verbal inhibition.

Conclusion

In conclusion, this review of metacognitive interventions in education reveals a complex landscape with various considerations. The quality of research designs, particularly in RCTs, varied, with many studies failing to account for class clustering, and some lacking a pure control group, which impacts the reliability and validity of their findings. Sample sizes also varied widely, potentially limiting the generalisability of results. Furthermore, some common bad practices were identified, such as comparing pre and post-tests within the same group, which can lead to flawed conclusions and lacks the rigor needed for robust causal inference.

The choice of metacognitive interventions and their impact depends on factors like developmental levels, domain specificity, intervention duration, and implementation methods. Studies indicate that metacognitive development is a gradual process, with various components evolving at different stages and being influenced by contextual factors. The focus on domain-specific interventions was prevalent, with mathematics and science being the most frequently examined disciplines. While this approach aligns with the specific cognitive demands of different subjects, it raises questions about the potential benefits of fostering more general metacognitive skills that can be applied across various learning situations.

The duration of interventions varied based on specific objectives and contextual factors, with short-term, medium-term, and long-term interventions having their own merits. Additionally, the implementation of interventions by researchers, or collaborative efforts between teachers and researchers has implications for the generalisability of their effectiveness when implemented in a school setting without researcher influence/input.

Based on the quality of theoretical underpinnings, practical aspects, and scientific rigor, seven metacognitive interventions stand out as promising options for deeper consideration. These interventions encompass a range of programs and have shown positive impacts on metacognitive knowledge and/or academic outcomes in different contexts.

In summary, the review highlights the importance of careful research design, thoughtful consideration of intervention characteristics, and an awareness of the specific needs and developmental stages of students. Metacognitive interventions have the potential to positively impact students' metacognitive skills and academic performance, but their effectiveness depends on a range of factors that should be carefully considered in future research and educational practice.

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Zepeda, C. D., J. Elizabeth Richey, P. Ronevich, and T. J. Nokes-Malach. 2015. 'Direct instruction of metacognition benefits adolescent science learning, transfer, and motivation: An in vivo study', *Journal of educational psychology*, 107: 954-70.

Zimmerman, B. J. 1995. 'Self-regulation involves more than metacognition: A social cognitive perspective', *Educational Psychologist*, 30: 217-21.

Appendix 1: Databases searched and limits applied

Table 3: Databases searched, search strings and limitations applied

Database	**Search string**	**Limits applied**	***n***	***n*-duplicates**
A+ Education	ABS(metacogniti* OR meta-cogniti*) AND ABS(intervention OR program* OR strateg*) AND ABS(student OR child*) AND ABS(school)	*Peer reviewed* *Publication date:* January 2003 to August 2023 *Access type:* Only show content I have access to	14	14
Cochrane Library	Title, abstract, keyword-(metacogniti* OR meta-cogniti*) AND Title, abstract, keyword-(intervention OR program*) AND Title, abstract, keyword-(student OR child*) AND Title, abstract, keyword-(school)	*Publication date:* January 2003 to August 2023	59	46
ERIC	ab(metacogniti* OR meta-cogniti*) AND ab(intervention OR program*) AND ab(student OR child*) AND ab(school)	*Language:* English *Peer reviewed* *Publication date:* after 1 January 2003 Document type: Guides-Classroom-Learner, Guides-Classroom-Teacher, Guides-Non-Classroom, ERIC Publications, Journal Articles, Reports-General, Reports-Evaluative, Reports-Research, Article, Report, Review, Government & Official Document, Statistics/Data Report *Education level*: Early childhood education, Elementary education, Elementary secondary education, Grade 1, Grade 2, Grade 3, Grade 4, Grade 5, Grade 6, Grade 7, Grade 8, Grade 9, Grade 10, Grade 11, Grade 12, High school equivalency programs, High schools,	4	4

		Intermediate grades, Junior high schools, Kindergarten, Middle schools, Primary education, Secondary education *Target audience:* Administrators, Community, Counsellors, Parents, Policymakers, Practitioners, Researchers, Support Staff, Teachers *Subject:* teaching methods, educational strategies, educational practices, classroom techniques, mathematics instruction, learning strategies, science instruction, physical education, problem solving, intervention, mathematics education, reading comprehension, elementary school teachers, inquiry, lesson plans, physical education teachers, science education, English (second language), instructional effectiveness, curriculum implementation		
Google (Grey Literature-Government Reports)	metacogniti* OR meta-cogniti* AND intervention OR program* AND student OR child* AND school		7	7
ProQuest Central	ABS(metacogniti* OR meta-cogniti*) AND ABS(intervention OR program*) AND ABS(student OR child*) AND ABS(school)	*Language:* English *Limit to:* Peer reviewed *Publication date:* after 1 January 2003 *Source type:* Reports, Scholarly Journals *Document type:* Article, Book Chapter *Publication title:* Education Sciences, Children, Early Childhood Education Journal, Journal of Educational Psychology, Education 3 – 13, International Journal of Science Education, British Educational Research Journal, Developmental Psychology, British Journal of Educational Technology, Journal of Science Education and Technology, Reading and Writing, British Journal of Educational Psychology, School	11	11

		Psychology Review, European Journal of Psychology Education, Child Development		
PubMed	Title/abstract-(metacogniti* OR meta-cogniti*) AND Title/abstract-(intervention OR program*) AND Title/abstract-(student OR child*) AND Title/abstract-(school)	*Year:* 2003 to 2023 *Language:* English *Age:* Child (6-12 years), Adolescent (13-18 years)	36	29
ScienceDirect	Title, abstract or author-specified words-(metacognition OR metacognitive) AND (intervention OR program) AND (student OR child) AND (school) (NOTE: Wildcards not supported in advanced search option. Database only allows for limited application of Boolean terms. Hyphens are unable to be used as the database reads it as the 'NOT' operator, therefore, 'meta-cognition' has been replaced with 'metacognitive')	*Year:* 2003 to 2023 *Article type:* Review articles, Research articles, Book chapters *Publication title*: Procedia – Social and Behavioural Sciences, International Journal of Educational Research, Learning and Instruction, Computers & Education, Thinking Skills and Creativity, Contemporary Educational Psychology, Behaviour Research and Therapy, Acta Psychologica, Journal of School Psychology, Social Sciences & Humanities Open, Studies in Educational Evaluation, Computers in Human Behavior, Teaching and Teacher Education, Library & Information Science Research, Journal of Applied Science Research, Journal of Applied Developmental Psychology, Cognitive Development, Trends in Neuroscience and Education, Journal of Safety Research *Subject areas:* Social Sciences, Psychology, Arts and Humanities, Decision Sciences, Neuroscience, Computer Science	45	36
Scopus	ABS(metacogniti* OR meta-cogniti*) AND ABS(intervention OR program*) AND ABS(student OR	*Year:* 2003 to 2023 *Language:* English *Subject area*: Psychology, Social sciences *Document type:* Article, Review, Book chapter	307	273

	child*) AND ABS(school)	*Keyword:* Child, Students, Education, Educational measurement, Childhood, Learning strategies, Metacognitive strategies, Adolescent, School child *Location*: Austria, Australia, Belgium, Canada, Chile, Colombia, Costa Rica, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkiye, the United Kingdom and the United States *Source type:* Scholarly journals, Dissertations and theses, Reports and books *Source title:* British Journal of Educational Psychology, Metacognition and Learning, Electronic Journal of Research in Educational Psychology, Journal of Research in Science Teaching, European Journal of Psychology of Education, International Electronic Journal of Elementary Education, International Journal of Educational Research, Frontiers in Education, Education Sciences, British Journal of Educational Technology, Metacognition Theory Performance and Current Research, Learning and Instruction, Journal of School Psychology, Journal of Research in Childhood Education, Journal of Educational Psychology, Journal of Cognition and Development, Journal of Adolescent and Adult Literacy, Japanese Journal of Educational Psychology, International Journal of Mathematical Education in Science and Technology, International Journal of Learning, International Journal of Early Years Education, Instructional Science, Asia Pacific Education Researcher, Thinking Skills and Creativity, Science		

		Education, Scandinavian Journal of Educational Research, Research Papers in Education, Research in Science and Technological Education, Reading and Writing, Psychology in the Schools, Mediterranean Journal of Social Sciences, International Journal of Science Education, International Journal of Science and Mathematics Education, International Journal of School and Educational Psychology, Curriculum Journal		

Table 4: Total records, duplications and exclusions by database

Database searched	**Total records**	**Post de-duplication**	**Excluded (first screening)**	**Unavailable**	**Records remaining**
A+ education	14	14	13		1
Cochrane Library	59	46	32		14
ERIC	4	4	3		1
Google (grey literature)	7	7	7		0
ProQuest Central	11	11	9		2
PubMed	36	29	23		6
ScienceDirect	45	36	25		11
Scopus	307	273	197	1	75
TOTAL	**483**	**420**	**309**	**1**	**110**

Exclusions criteria applied:

- Literature published prior to 1 January 2003
- Qualitative literature
- Studies conducted in countries outside the OECD
- Interventions/programs/strategies used for students with learning difficulties and/or disabilities

Inclusion criteria applied:

- Literature published on and after 1 January 2003
- Studies conducted in OECD countries
- Practicality of interventions/programs/strategies for primary and/or secondary school classrooms
- Quantitative literature
- Peer reviewed

Appendix 2: Data Extraction Tables

Table 5: Artificial Peer Learning Environment using SimStudent (APLUS)

Name and type of intervention: APLUS (Artificial Peer Learning Environment Using SimStudent), APLUS TUTOR & COG TUTOR+
Description of the intervention: (1) APLUS • An online learning environment where students learn to solve equations by teaching a synthetic peer. The synthetic peer is visualised as an avatar in the lower left corner of the screen. Students can customise their avatar. SimStudent is a machine learning agent that interactively learns skills to solve problems through guided problem-solving. • Allows students to interactively teach a synthetic peer with a goal to have the synthetic peer pass the quiz while the system provides students with metacognitive scaffolding on how to teach. • The goal is for students to have their SimStudent pass the quiz. • Includes a teacher agent (a meta-tutor) which provides students with help on how to appropriately tutor SimStudent (called *metacognitive tutoring help*). (2) APLUS TUTOR • Provides cognitive tutoring and metacognitive scaffolding on how to learn. • Students select problems from the Problem Bank or make them up and enter them into the Tutoring Interface themselves. • The goal for students using APLUS TUTOR is to solve all quiz problems correctly by themselves. (3) COG TUTOR+ • Provides traditional cognitive tutoring in mastery learning. • A cognitive tutor that has the same graphical interface as APLUS. • The goal for a student using COG TUTOR+ is to achieve a mastery proficiency level for all nine skills.
First record (full reference, must contain detailed methods, including details of implementation and evaluation): Matsuda, N., Weng, W., & Wall, N. (2020). The Effect of Metacognitive Scaffolding for Learning by Teaching a Teachable Agent. *International Journal of Artificial Intelligence in Education*, *30*(1), 1-37. https://doi.org/10.1007/s40593-019-00190-2
Outcomes measured: - Learning outcomes (test scores): Procedural Skill Test and Conceptual Knowledge Test - Frequency of metacognitive help received

Strengths:	
- Online program makes it scalable for use across DfE schools. - System provides students with corrective feedback on quiz solutions. - Provides metacognitive scaffolding. - Learning by teaching looks to be a promising style of learning.	
Limitations: - Students require some conceptual knowledge of algebraic reasoning.	
Adaptions made to original intervention/program:	**Record:**
N/A	N/A
Related records: N/A	

Table 6: AstroWorld

Name and type of intervention: AstroWorld
Description of the intervention: - A metacognitive scaffolding protocol. - Delivered via two methods: (1) administered by a human facilitator at individualised level of one pair of students, and (2) administered at classroom level. - Utilises an intervention scenario, AstroWorld, to guide students by means of questioning without giving them explicit instruction regarding strategies. Objective is to challenge students' to reflect on their claims whilst providing continual metacognitive supports individualised toe their current level of progress. - Intervention contains three phases. (1) *Control of variables phase* – scenario activity where students were required to select best applicants to reside in a space station for several months. Pairs were then asked to choose amongst 24 applicant records to examine and determine which four applicant characteristics make a difference to outcome and which don't. (2) *Multivariable coordination phase* – charts were introduced as a method for examining more than 2 to 3 applicant records at a time. (3) *Application phase* – pairs were asked to predict outcomes for new applicants based on their records and justify them. - A Life Expectancy tasked introduced as a post-intervention assessment. Assesses same multivariable analysis and prediction skills as contained in AstroWorld, but involves unrelated content. Documents students' gains in skills. - Intervention administered to the classroom condition on a fixed schedule of ten 45-minute class sessions over 16 days. The number of sessions in individualised condition varied as it was self-paced, ranged from four to seven sessions over 14–59 days. - Study 2 pursues goal of scalability by use of technology to fulfill role of human facilitator (n=64 for this study). Goals and activities are same as those in Study 1. Facilitator introduced Astro-world program to class using a PowerPoint presentation. The program contains a chat program on the lefthand side of the screen where an automated agent 'chats' with the student pair. The automated agent also periodically reminds students to discuss and agree before responding and if students struggle, it progressively rephrases the prompt by becoming more explicit. The same post-test was used as in Study 1.
First record (full reference, must contain detailed methods, including details of implementation and evaluation): Arvidsson, T. S., & Kuhn, D. (2021). Realizing the full potential of individualizing learning. *Contemporary Educational Psychology*, *65*, 101960. https://doi.org/https://doi.org/10.1016/j.cedpsych.2021.101960
Outcomes measured: - Control of variables (COV)

<table>
<tr><td colspan="2">Strengths:
- The online program (Study 2) allows the intervention to be scaled up.
- Challenges students to re-evaluate their solutions from another point of view.
- Challenges students within their own zones of proximal development.
- Authors indicate that the intervention was successful in terms of sustained engagement amongst low-performing student participants.</td></tr>
<tr><td colspan="2">Limitations:
- Time consuming if delivered via the individualised method (part of Study 1).
- Unclear how metacognition was assessed throughout the intervention.</td></tr>
<tr><td>Adaptions made to original intervention/program:</td><td>Record:</td></tr>
<tr><td>N/A</td><td>N/A</td></tr>
<tr><td colspan="2">Related records:

Kuhn, D., Arvidsson, T. S., Lesperance, R., & Corprew, R. (2017). Can engaging in science practices promote deep understanding of them? Science Education, 101, 232–250.</td></tr>
</table>

Table 7: Attention Training Technique (ATT)

Name and type of intervention:
Attention Training Technique (ATT)

Description of the intervention:

- A recorded version of Wells' (1990) Attention Training Technique (ATT) was used and standardised instructions for delivery were provided to class teachers. They were instructed to play an ATT recording on any three separate occasions during the four-day intervention period. The ATT consists of approximately 11 minutes of sounds (such as bird song, traffic, clock ticking) and a voice which instructs participants to direct attention in specific ways, for example, from one sound to another and to different spatial locations.
- Schools provided a room for data collection to take place undisturbed. Chairs and tables were arranged to ensure the child would be positioned in front of the treat and so that the written activities could be undertaken.
- For the primary outcome of the Marshmallow Test, there were two types of treats, a chocolate button and a Haribo sweet to ensure that the treat was desired by the child. A stopwatch was used to time the 13 minutes the child had to wait alone in the room.
- The following measures were also administered: to assess executive control the day/night tasks was used. This consists of a set of 20 day and night cards (four practice cards and 16 test cards). The participant is instructed to say "day" when a picture of the moon is presented and "night" when the sun is presented and the number of errors are measured. To assess the mood the Faces Scale was used. This comprises a five-point self-report scale and children are asked to select the face which best represents their thoughts and feelings in response to three questions: (1) "most of the time I feel", (2) "compared to other people I feel" and (3) "right now I feel".

First record (full reference, must contain detailed methods, including details of implementation and evaluation):
Murray, J., Theakston, A., & Wells, A. (2016). Can the attention training technique turn one marshmallow into two? Improving children's ability to delay gratification. *Behaviour Research and Therapy*, *77*, 34-39. https://doi.org/10.1016/j.brat.2015.11.009

Outcomes measured:

- Inhibitory control (delay of gratification) and mood

Strengths:

Limitations:

- Time consuming as training is conducted one-on-one with each student.
- Scales not sensitive enough to capture improvement in inhibitory control and mood.

Adaptions made to original intervention/program:	**Record:**
- Original technique was used with adults who were being treated for anxiety disorders.	Wells, A. (1990). Panic disorder in association with relaxation induced anxiety: an attentional training approach to treatment. *Behavior Therapy*, 21, 273-280.

- Replication and extension of Murray et al. (2016) study. - Includes enhanced additional parameters of executive control. - Inclusion of an active control, Progressive Muscle Relaxation (PMR).	Murray, J., Scott, H., Connolly, C., & Wells, A. (2018). The Attention Training Technique improves Children's ability to delay gratification: a controlled comparison with progressive relaxation. *Behaviour Research and Therapy*, *104*, 1-6. https://doi.org/10.1016/j.brat.2018.02.003
Related records: N/A	

Table 8: BE Organised

<table>
<tr><td colspan="2">Name and type of intervention:
BE Organised</td></tr>
<tr><td colspan="2">Description of the intervention:
- A program created by Beyond Education based on the Four-Dimension Educational Model from the Centre for Curriculum Redesign.
- Each program targets 3 to 5 core competencies to develop out of the 12 possible cognitive-socio-emotional competencies.
- This program spans a duration of 8 weeks, containing 12 individual sessions aimed at developing 4 core competencies: Critical Thinking (Skills), Metacognition (Meta-learning), Mindfulness (Character) and Resilience (Character).
- Each 30-45 minute session targets one sub-competency within the four core competencies. These individual sessions contain videos, activities and games to engage various senses of the students and are intertwined with knowledge about current and contextual information.
- In addition to the individual sessions, students also participate in seven group sessions or "Action Labs" which is a virtual space for collaborative work on current issues.</td></tr>
<tr><td colspan="2">First record (full reference, must contain detailed methods, including details of implementation and evaluation):
Maoulida, H., Madhukar, M., & Celume, M. P. (2023). A Case Study of 21st Century Cognitive, Social and Emotional Competencies Using Online-Learning. Journal of Intelligence, 11(6), Article 116. https://doi.org/10.3390/jintelligence11060116</td></tr>
<tr><td colspan="2">Outcomes measured:
-</td></tr>
<tr><td colspan="2">Strengths:
- An online program which is scalable.
- Allows students to collaborate in virtual spaces.</td></tr>
<tr><td colspan="2">Limitations:
- Hasn't been evaluated for use with students in OECD countries.</td></tr>
<tr><td>Adaptions made to original intervention/program:</td><td>Record:</td></tr>
<tr><td>N/A</td><td>N/A</td></tr>
<tr><td colspan="2">Related records:
N/A</td></tr>
</table>

Table 9: Becoming Original: Divergent Thinking Strategy Instruction

<table>
<tr><td colspan="2">Name and type of intervention:
Becoming original: divergent thinking strategy instruction</td></tr>
<tr><td colspan="2">Description of the intervention
Intervention was designed for upper secondary art students, aiming at enhancing their divergent thinking skills, in particular, their fluency, flexibility and originality. It took place as part of a 14 week photography project, which was part of the regular visual arts curriculum for the students. In week 4 or 5 of the project, each of two groups received one 50-minute intervention lesson, which was the metacognitive lesson for the experimental group and a brainstorming lesson for the control. For both groups, this was conducted by the researcher, who was one of two teachers taking the class(es). The metacognitive lesson was conducted in five phases:
- orientation on metacognitive knowledge;
- metacognitive strategy instruction;
- divergent thinking strategy instruction;
- application of strategies;
- evaluation and reflection.</td></tr>
<tr><td colspan="2">First record (full reference, must contain detailed methods, including details of implementation and evaluation):
van de Kamp, M. T., Admiraal, W., & Rijlaarsdam, G. (2016). Becoming original: effects of strategy instruction [Article]. Instructional Science, 44(6), 543-566. https://doi.org/10.1007/s11251-016-9384-y</td></tr>
<tr><td colspan="2">Outcomes measured:
Fluency, flexibility and originality of divergent thinking, as measured by computerised “alternative uses” tests. Testing conducted 3 weeks pre- and 4 weeks post- intervention.</td></tr>
<tr><td colspan="2">Strengths:
Intervention had intended effect of increasing the measured aspects of divergent thinking.</td></tr>
<tr><td colspan="2">Limitations:
Domain-specific. Limited outcomes tested. Very short intervention (1 lesson).</td></tr>
<tr><td>Adaptions made to original intervention/program:</td><td>Record:</td></tr>
<tr><td>Content modified in effort to increase originality of divergent thinking (as well as other aspects).</td><td>van de Kamp, M. T., Admiraal, W., van Drie, J., & Rijlaarsdam, G. (2015). Enhancing divergent thinking in visual arts education: Effects of explicit instruction of meta-cognition [Article]. British Journal of Educational Psychology, 85(1), 47-58. https://doi.org/10.1111/bjep.12061</td></tr>
<tr><td colspan="2">Related records:
N/A</td></tr>
</table>

Table 10: Computer-Delivered Support – Physhint program

Name and type of intervention: Computer-Delivered Support – Physhint program
Description of the intervention: - A web-based computer program which supports novices attempting to solve physics problems concerned with forces. - Computer-delivered hints in relation to problem-solving abilities in two alternative indirect instruction schemes. In one instruction scheme, hints are available to students immediately after they are given a new problem to solve as well as after they have completed the problem. In the other scheme, hints are only available as worked out problems after students have finished their solution. The instruction schemes are supplied by means of a web-based program, Physhint, which supports the development of strategic knowledge. - The aim of the program is to enhance the development of problem-solving abilities by offering problems that can be completed with the help of the program. The help is structured according to Schoenfeld's five episodes of systematic problem-solving: survey the problem (read, analyse), activate knowledge (explore), make a plan (plan), carry out the plan (implement) and check the answer (verify). - The program does not dictate strict problem-solving steps but gives students room to develop an individual problem-solving strategy.
First record (full reference, must contain detailed methods, including details of implementation and evaluation): Pol, H. J., Harskamp, E. G., Suhre, C. J. M., & Goedhart, M. J. (2009). How indirect supportive digital help during and after solving physics problems can improve problem-solving abilities. *Computers and Education*, *53*(1), 34-50. https://doi.org/10.1016/j.compedu.2008.12.015
Outcomes measured: - Students' problem-solving behaviours - Strategic knowledge
Strengths: - Designed to be a flexible program to fit with individual student's learning, i.e., students are in control of their own instruction and for selecting what kind of help they need.
Limitations: - Limited sample size.

Adaptions made to original intervention/program:	**Record:**
N/A	N/A

Related records: N/A

Table 11: ConText

Name and type of intervention: ConText: A computer program based on latent semantic analysis (LSA)
Description of the intervention: - ConText aims at improving executive metacognition. - A computer-assisted and content-focused intervention that features a guided practice approach in order to grasp the meaning of a text, specifically by giving computer-based feedback on written summaries. - It is based on LSA, a statistical technique from the field of natural language processing which permits the semantic relations between words based on their common occurrences in texts. - Contains different steps which follow a sequential order: at the beginning a short instruction is displayed that gives recommendations on how to best summarise a text and briefly explains the usage of the computer tutor. Next, student reads the source text which they then summarise. Program flags spelling mistakes and plagiarised passages. Next, all sentences with a high semantic similarity are underlined. In the final step, the tutor displays an evaluation of the content coverage of the source text and indicates which parts of the original text have not been sufficiently represented in the summary. At this point, the student has the opportunity to revise their draft and improve the summary. The system gathers the drafts of the different revision cycles and students is provided with an overview indicating how scores have evolved from revision to revision. - ConText can operate as a stand-along desktop application as well as a web-based e-learning environment.
First record (full reference, must contain detailed methods, including details of implementation and evaluation): Lenhard, W., Baier, H., Endlich, D., Schneider, W., & Hoffmann, J. (2013). Rethinking strategy instruction: Direct reading strategy instruction versus computer-based guided practice [Article]. *Journal of Research in Reading*, *36*(2), 223-240. https://doi.org/10.1111/j.1467-9817.2011.01505.x
Outcomes measured: - Reading comprehension - Metacognitive knowledge in reading - Reading fluency - Verbal intelligence
Strengths: - Provides students with instant feedback. - Scalable - Can be embedded into regular coursework by using subject-specific texts. - Works with short 150-word texts. - Uses a guided practice approach.

Limitations:	
- Relies on students’ reading comprehension skills.	
Adaptions made to original intervention/program:	**Record:**
N/A	N/A
Related records:	
N/A	

Table 12: Direct Instruction of Metacognition

Name and type of intervention: Direct Instruction of Metacognition
Description of the intervention: - Puzzle problems used for first round of intervention, emphasising problem-solving and metacognitive skills. Consisted of spatial and verbal insight problems, riddles, rebus word problems and simple mathematics problems. All students were given the same initial problem, followed by a hint, another opportunity to solve it, and the solution. At the end of each packet, all students were given a transfer problem with a similar structure to that of the initial problem. - **Packets 1–4: experimental.** In the first packet, students studied an explanation of planning, reviewed worked examples of plans, responded to questions about their own planning activities, and created a plan to solve a new problem (see Table 1). In the second packet, students studied an explanation of monitoring, reviewed and analysed fictional students' attempts to solve prob- lems, and responded to questions about their own monitoring activities (see Table 1). In the third packet, students studied an explanation of evaluating and responded to prompts to evaluate their solutions (see Table 1). In the fourth packet, students re- viewed descriptions of planning, monitoring, and evaluating, read about how to integrate the three skills when problem solving, and responded to prompts and questions targeting all three skills (see Table 1). Unlike the other packets, Packet 4 concluded with two transfer problems instead of one. - **Packets 1–4: control**. Control materials also consisted of puzzle problems. The packets did not include any instruction on planning, monitoring, or evaluating, but instead instructed students that they could improve their general problem-solving skills by working through the packets. The initial problem for each packet was the same as in the experimental materials. Following the initial problem, packets were divided into sections of problems. At the end of each section, students were given solutions and encouraged to check their answers before continuing on to the next section of problem solving. Piloting work revealed that the problems within each packet differed in the amount of time it took to complete them; consequently, the first packet had seven problems, the second had 13, the third had 16, and the fourth had seven. In round two of the intervention, instruction was integrated from round one into a series of physics problems that were adapted from the students' physics textbook. Each packet focused on different physics concepts about which the students had previously received instruction. The first packet consisted of problems that required students to calculate the average speeds of two objects. The second packet contained conservation of momentum problems. The third packet contained problems that required students to apply Newton's second law to calculate speed, acceleration, and distance for a single falling object. The fourth packet required students to apply Newton's second law to calculate weight, acceleration, and time for pairs of falling objects.
First record (full reference, must contain detailed methods, including details of implementation and evaluation): Zepeda, C. D., Elizabeth Richey, J., Ronevich, P., & Nokes-Malach, T. J. (2015). Direct instruction of metacognition benefits adolescent science learning, transfer, and motivation: An in vivo study. *Journal of Educational Psychology*, *107*(4), 954-970. https://doi.org/10.1037/edu0000022
Outcomes measured: - Metacognitive awareness - Students' achievement goal orientations

- Self-efficacy - Problem-solving	
Strengths: - Modest gains in participants' declarative knowledge of metacognitive skills. - Findings suggest increases in participants' conceptual knowledge.	
Limitations: - Domain specific intervention (Physics). - Small sample size together limits generalisability of findings.	
Adaptions made to original intervention/program:	**Record:**
N/A	N/A
Related records: N/A	

Table 13: E-Learning with IMPROVE

<table>
<tr><td colspan="2">Name and type of intervention:
E-learning with IMPROVE</td></tr>
<tr><td colspan="2">Description of the intervention
The intervention replaced usual classes for one mathematics unit (linear functions) in an Israeli junior high school. One class group was receive an e-learning intervention and another received e-learning supported by IMROVE. Each received four 90-minute classes for five weeks, two of which were ‘regular’ maths classes, and the other two e-learning classes. The e-learning environment consisted of interactive problem solving tasks, developed in Excel; students worked on these (mostly) in pairs, sent solutions to the teacher, and were provided with support and feedback.
The e-learning plus IMPROVE group were, further, instructed in and engaged in activities based on the IMPROVE framework; specifically, self-metacognitive questioning, mathematical explanations, and e-learning metacognitive feedback. Instruction, support, and prompting was provided by the teacher, and also embedded in the e-learning environment in the form of metacognitive questioning during the solution process and feedback afterwards.</td></tr>
<tr><td colspan="2">First record (full reference, must contain detailed methods, including details of implementation and evaluation):
Kramarski, B., & Gutman, M. (2006). How can self-regulated learning be supported in mathematical E-learning environments? Journal of Computer Assisted Learning, 22(1), 24-33. https://doi.org/https://doi.org/10.1111/j.1365-2729.2006.00157.x</td></tr>
<tr><td colspan="2">Outcomes measured:
Mathematical performance (33-item test with procedural, transfer, and explanation components) and self-regulated learning (questionnaire), both pre- and post-intervention.</td></tr>
<tr><td colspan="2">Strengths:
Students receiving the metacognitive component showed greater improvement over the e-learning-only group in problem solving (procedural and transfer tasks) and mathematical explanations.</td></tr>
<tr><td colspan="2">Limitations:
Domain specific. Short duration. Small sample: two classes (different teachers), one school. Persistence not investigated.</td></tr>
<tr><td>Adaptions made to original intervention/program:</td><td>Record:</td></tr>
<tr><td>Implemented in and adapted to e-learning environment.</td><td>Mevarech Z.R. & Kramarski B. (1997) IMPROVE: a multidimensional method for teaching mathematics in heterogeneous classrooms. American Educational Research Journal 34, 365–394.</td></tr>
<tr><td colspan="2">Related records:
N/A</td></tr>
</table>

Table 14: Explicit Instruction of Metacognition in Visual Arts Education

<table>
<tr><td colspan="2">Name and type of intervention:
Explicit instruction of metacognition in visual arts education</td></tr>
<tr><td colspan="2">Description of the intervention
Intervention was designed for upper secondary art students, aiming at enhancing their divergent thinking skills. It took place as part of a 19-week project, which was part of the regular arts curriculum for the students. In week 5 or 9 of the project, each of two groups received one 50-minute intervention lesson, which was the metacognitive lesson for the experimental group and assignments pertaining to the usual curriculum (focusing on art reception, production, and reflection) for the control. For both groups, this was conducted by the researcher, who was one of two teachers taking the class(es). The metacognitive lesson was conducted as follows:
- activating prior knowledge of creativity;
- constructing cognitive and metacognitive knowledge;
- constructing conceptual knowledge of creativity and thinking strategies;
- constructing higher order knowledge about divergent thinking strategies;
- practising and evaluating divergent thinking.</td></tr>
<tr><td colspan="2">First record (full reference, must contain detailed methods, including details of implementation and evaluation):
van de Kamp, M. T., Admiraal, W., van Drie, J., & Rijlaarsdam, G. (2015). Enhancing divergent thinking in visual arts education: Effects of explicit instruction of meta-cognition [Article]. British Journal of Educational Psychology, 85(1), 47-58. https://doi.org/10.1111/bjep.12061</td></tr>
<tr><td colspan="2">Outcomes measured:
Fluency, flexibility and originality of divergent thinking, as measured by computerised “verbal instances” tests. Testing conducted pre- and 2-6 weeks post- intervention.</td></tr>
<tr><td colspan="2">Strengths:
Intervention had some of intended effect of increasing fluency and flexibility of thinking.</td></tr>
<tr><td colspan="2">Limitations:
Domain-specific. Limited outcomes tested. Very short intervention (1 lesson).</td></tr>
<tr><td>Adaptions made to original intervention/program:</td><td>Record:</td></tr>
<tr><td>N/A</td><td></td></tr>
<tr><td colspan="2">Related records:
N/A</td></tr>
</table>

Table 15: Feuerstein Instrumental Enrichment (FIE) Program

Name and type of intervention:
Feuerstein Instrumental Enrichment (FIE) program

Description of the intervention
Intervention implemented over one school year by teachers during usual school hours. Each week, two hours a week of usual curriculum were replaced by the Feuerstein Instrumental Enrichment (FIE) program; students also had the same teacher, applying the FIE principles, for at least one other subject (from English, maths and Arabic). The FIE principles include an explicit focus on metacognition; e.g. "learning through focused teaching of learning strategies and thinking skills" (current record), "The production of insight and understanding of one's own thought processes, in particular those processes that produce success and are responsible for failure" (from related record below).
The intervention used three instruments from the FIE (teachers were trained using 15). The instruments are non-curriculum-based tasks designed to build students' learning and thinking processes, with the teacher engaging in "mediating dialogue". Teachers received 60 hours of training prior to implementation of the intervention, and continuing training (twice per month) for the duration of the intervention.

First record (full reference, must contain detailed methods, including details of implementation and evaluation):
Tzuriel, D., Cohen, S., Feuerstein, R., Devisheim, H., Zaguri-Vittenberg, S., Goldenberg, R., Yosef, L., & Cagan, A. (2023). Evaluation of the Feuerstein Instrumental Enrichment (FIE) program among Israeli-Arab students [Article]. *International Journal of School and Educational Psychology*, *11*(1), 95-110. https://doi.org/10.1080/21683603.2021.1951409

Outcomes measured:
Performance (grades) in three school subjects: English, Arabic, and Mathematics. Recorded before and after the intervention.

Strengths:
Comprehensive, domain general intervention. Students' performance in maths improved compared to the control. Effective for students with lower cognitive abilities (as measured pre-intervention), even when replacing usual content-based learning.

Limitations:
Took two hours per week from usual content-based curriculum. Requires extensive teacher training. No significant benefit found for students with higher cognitive abilities (as measured pre-intervention).

Adaptions made to original intervention/program:	**Record:**
Applied to general group of students (not only those with learning difficulties). Only 3 of 15 instruments used.	Feuerstein, R., Miller, R., Hoffman, M. B., Rand, Y., Mintzker, Y., & Jensen, M. R. (1981). Cognitive Modifiability in Adolescence: Cognitive Structure and the Effects of Intervention. *The Journal of Special Education*, *15*(2), 269–287. https://doi.org/10.1177/002246698101500213

Related records:
N/A

Table 16: Homework Focused SRL Training

Name and type of intervention: Homework-focused SRL training	
Description of the intervention The intervention was conducted by teachers during usual school classes over five weeks, following a three-day training seminar. Classroom learning materials were provided by researchers. The intervention was homework-focused. Students were introduced to Zimmerman's cycle of self-regulated learning in class via activity sheets and discussions and were further given activity sheets on "homework skills", including organisational and regulatory strategies, and tips on dealing with distractions. They received maths homework exercises each day, based on topics currently covered in usual classes. They were asked to predict their performance prior to completing the exercises and then evaluate their performance against their predictions each subsequent day. A weekly quiz was given, with the same process of prediction and post-performance evaluation and in the first week, students completed a "homework behaviour" questionnaire. This was used in the second week to compare behaviour and performance, and subsequently develop strategies using the SRL framework. A control group received no intervention.	
First record (full reference, must contain detailed methods, including details of implementation and evaluation):	
Outcomes measured: Mathematics achievement (pre and post intervention tests). Homework behaviour, self-efficacy, interest in mathematics, effort willingness, learning goal orientation, helplessness (all via questionnaire pre and post intervention).	
Strengths: The treatment was found effective in increasing self-efficacy and self-regulation, and decreasing helplessness.	
Limitations: Amount of homework involved not transferrable to Australian context (primary school hours are much shorter in Germany).	
Adaptions made to original intervention/program:	**Record:**
Earlier similar intervention, with particular focus on motivational orientations.	Stoeger, H., & Ziegler, A. (2006). On the influence of motivational orientations on a training to enhance self-regulated learning skills. *Education Sciences and Psychology*(2), 13-27.
Earlier similar intervention, with more focus on performance growth.	Stoeger, H., & Ziegler, A. (2008). Evaluation of a classroom based training to improve self-regulation in time management tasks during homework activities with fourth graders. *Metacognition and Learning*, *3*(3), 207-230. https://doi.org/10.1007/s11409-008-9027-z
Related records: N/A	

Table 17: IMPROVE

Name and type of intervention:
IMPROVE

Description of the intervention:

- A multidimensional instructional method aimed at enhancing mathematical reasoning.
- The method involves three interdependent components: (a) facilitating both strategy acquisition and metacognitive processes; (b) learning in cooperative teams of four students with different prior knowledge: one high, two middle, and one low-achieving student; and (c) provision of feedback-corrective- enrichment that focuses on lower and higher cognitive processes.
- IMPROVE is an acronym of the teaching steps that constitute the method: Introducing new concepts, Metacognitive questioning, Practicing, Reviewing and reducing difficulties, Obtaining mastery, Verification and Enrichment.
- After the teacher introduces new concepts to whole class, students work in small groups.
- Student turn-taking in asking and answering three kinds of metacognitive questions: comprehension questions, strategic questions, and connection questions.
- *Comprehension questions* oriented the students to articulate the main ideas in the problem (e.g., "Describe . . . in your own words"), classify the problem into an appropriate category (e.g., "This is a rate problem of the form cost-per-unit rate"; "This is a simplification problem with a negative multiplier"), and elaborate the new concepts (e.g., "The definition of... is ..."; "The meaning of. . . is . . ."; "The given are . . .";"The unknown is . . . ").
- *Strategic questions* refer to strategies appropriate for solving the problem. When the unit focuses on specific mathematics principles, students have to select the principle, justify their decision, and describe the application of the principle to the given problem. When the unit focuses on algebra word problems, students are prompted to use diagrams and tables.
- *Connection questions* refer to the similarities and differences between the problem at hand and the problems they have previously solved. Using connection questions, students learned to distinguish between *equivalent problems* sharing the same mathematical structure and the same story context, *similar problems* sharing the same story context but having different mathematical structures, *isomorphic problems* sharing the same mathematical structures but having a different story context, and *unrelated problems* sharing neither the mathematical structure nor the story context.

First record (full reference, must contain detailed methods, including details of implementation and evaluation):
Mevarech, Z. R., & Kramarski, B. (1997). IMPROVE: A Multidimensional Method for Teaching Mathematics in Heterogeneous Classrooms. *American Educational Research Journal*, *34*(2), 365-394. https://doi.org/10.3102/00028312034002365

Outcomes measured:

- Mathematical reasoning

Strengths:

- Implemented in heterogeneous classrooms where students from different backgrounds and with different knowledge learn together.
- Some indication that standardised scores increased for schools participating in IMPROVE.

- Sample size would indicate that intervention is scalable.
Limitations: - Significant reliance on students' verbal skills. - The extent to which students can transfer their knowledge to solving problems in other areas of mathematics curriculum (intervention focuses on algebra).

Adaptions made to original intervention/program:	**Record:**
- Smaller sample size (61) and tested within a single-sex school (all girls). - Trialled with an older age group. Median age of participants was 16.7.	Mevarech, Z. R., & Amrany, C. (2008). Immediate and delayed effects of meta-cognitive instruction on regulation of cognition and mathematics achievement [Article]. *Metacognition and Learning*, *3*(2), 147-157. https://doi.org/10.1007/s11409-008-9023-3

Related records: Mevarech, Z. R., & Amrany, C. (2008). Immediate and delayed effects of meta-cognitive instruction on regulation of cognition and mathematics achievement [Article]. *Metacognition and Learning*, *3*(2), 147-157. https://doi.org/10.1007/s11409-008-9023-3

Table 18: IMPROVE versus What, When, Why and How? (WWWH)

Name and type of intervention: IMPROVE versus What, When, Why and How? (WWWH)	
Description of the intervention: The intervention replaced usual mathematics classes (three 45-minute sessions per week) for three weeks, although three lessons were used for testing, meaning only six were devoted to the treatments. Two groups received different metacognitive interventions. One group's treatment was based on the generic self-directed question prompts of the IMPROVE framework, and the other on context-specific prompts in the form of "What…?", "When…?", "Why…?", and "How…?" (WWWH). The WWWH questions refer explicitly to a specific content area and give students hints directed toward the solution process, such as strategy use. Usual teachers conducted the intervention, receiving three hours of training prior to the intervention. In both groups, students were given cards printed with the question prompts. Teachers explained the importance of using the prompts as a tool to enhance their problem solving process, and modelled the use of the prompts. Students were encouraged to refer to their printed prompts along all three phases of the solution: planning, monitoring, and evaluation.	
First record (full reference, must contain detailed methods, including details of implementation and evaluation): Kramarski, B., Weiss, I., & Sharon, S. (2013). Generic Versus Context-Specific Prompts for Supporting Self-Regulation in Mathematical Problem Solving Among Students with Low or High Prior Knowledge. *J Cogn Educ Psych*(2), 197-214. https://doi.org/10.1891/1945-8959.12.2.197	
Outcomes measured: Algebraic procedural knowledge (immediately after intervention) Verbal problem solving (two months after intervention) Mathematical literacy – via a pencil and paper problem solving test, both pre- and post-intervention and an additional task for online groups, administered during online discussion. Self regulated learning, via questionnaire pre- and post- intervention.	
Strengths: Compares two different types of metacognitive intervention and finds different strengths (IMPROVE better for far-transfer and WWWH for near-transfer).	
Limitations: Domain specific. Short duration. Small sample size (two classes). No control.	
Adaptions made to original intervention/program:	**Record:**
The context-specific group of this previous version was focused on analysing and discussing conceptual errors (as compared to the IMPROVE approach alone, and also combined with IMPROVE). The current record expands the context-specific approach, as detailed above.	Kramarski, B., & Zoldan, S. (2008). Using Errors as Springboards for Enhancing Mathematical Reasoning With Three Metacognitive Approaches. *The Journal of Educational Research*, *102*(2), 137-151. https://doi.org/10.3200/JOER.102.2.137-151
Current intervention compares IMPROVE to the WWWH approach.	Mevarech Z.R. & Kramarski B. (1997) IMPROVE: a multidimensional method for teaching mathematics in heterogeneous classrooms. *American Educational Research Journal* 34, 365–394.
Related records: N/A	

Table 19: iSTART

Name and type of intervention: iSTART – a web-based training program that can be scaled up to serve large-scale needs	
Description of the intervention: - iSTART is composed of three sections: (1) introduction, (2) demonstration and (3) practice. Each section provides progressively more interaction with the trainee in regard to reading strategy use while self-explaining text. The purpose of the iSTART trainer is to provide readers with strategies to comprehend texts at a deeper level and provides the trainee with these abilities by teaching reading strategies in a scaffolded, structured manner. Eavh section is hosted by animated pedagogical agents that provide the trainee with guidance and instruction using speech and gestures. At first the agents provide self-explanations whilst the trainee watches, but as the trainee progresses through the model, they create self-explanations that are evaluated by the agents.	
First record (full reference, must contain detailed methods, including details of implementation and evaluation): McNamara, D. S., O'Reilly, T., Rowe, M., Boonthum, C., & Levinstein, I. (2007). iSTART: A Web-Based Tutor That Teaches Self-Explanation and Metacognitive Reading Strategies. In *Reading Comprehension Strategies: Theories, Interventions, and Technologies* (pp. 397-420). https://doi.org/10.4324/9780203810033-20	
Outcomes measured: -	
Strengths: - Can be scaled up. - Provides students with instant feedback. - Skills it teaches are primarily metacognitive in nature. - Teaches students about metacognitive reading strategies and how to use them. - Provides students with a safe, low-stakes environment.	
Limitations: - Authors suggest that more extensive training is required for low skilled student readers.	
Adaptions made to original intervention/program:	**Record:**
N/A	N/A
Related records: N/A	

Table 20: L1-Assisted Reciprocal Teaching

<table>
<tr><td colspan="2">Name and type of intervention:
L1-assisted reciprocal teaching</td></tr>
<tr><td colspan="2">Description of the intervention
Subjects of the intervention were recent (< 3 years) Taiwanese migrants to New Zealand in early secondary school for whom English was a second language. Following a five-day baseline assessment of English reading comprehension, intervention was 15 or 20 days (one 1-hour session each day) of modified L1-assisted reciprocal teaching over 4 or 5 weeks, with Mandarin (L1) and English reciprocal teaching occurring on alternate days. On each day, a fifteen-minute session of explicit strategy instruction was followed by a twenty-minute reciprocal teaching dialogue (in the same language) and then a comprehension test. New concepts and strategies given in the explicit instruction were introduced initially in Mandarin and then revisited on the following day in English.
Training covered (in order):
- purpose and format of the comprehension program;
- communication skills for group discussion;
- the reading process; reading goals;
- overview of reading strategies: questioning, summarising, clarifying and predicting;
- application of strategies via focus on top-level structure: comparison, causation, problem/solution and collection of descriptions.

In the reciprocal teaching dialogues, the teacher initially modelled the use of the reading strategies, and then the students took turns in the teacher's role, supported by the teacher with prompts, praise, explanation, etc as required.
Follow up testing was conducted over three sessions, 3-4 weeks after the intervention ended.</td></tr>
<tr><td colspan="2">First record (full reference, must contain detailed methods, including details of implementation and evaluation):
Fung, I. Y. Y., Wilkinson, I. A. G., & Moore, D. W. (2003). L1-assisted reciprocal teaching to improve ESL students' comprehension of English expository text [Article]. Learning and Instruction, 13(1), 1-31. https://doi.org/10.1016/S0959-4752(01)00033-0</td></tr>
<tr><td colspan="2">Outcomes measured:
- Reading comprehension in English, via standardised (Neale) and researcher-developed tests
- Prompted think-aloud tasks, to determine use of metacognitive strategy in processing text (English and Chinese)
- Transfer test, intended to measure students' ability to transfer comprehension strategies to novel tasks (in English)</td></tr>
<tr><td colspan="2">Strengths:
Explicit instruction in L1 and L2 effective in the ESL setting; some evidence of transfer of metacognitive skills.</td></tr>
<tr><td colspan="2">Limitations:
Small sample size; lack of follow-up post-intervention; limited to ESL setting; requires teachers fluent in students' first language as well as English.</td></tr>
<tr><td>Adaptions made to original intervention/program:</td><td>Record:</td></tr>
<tr><td>N/A</td><td></td></tr>
<tr><td colspan="2">Related records: N/A</td></tr>
</table>

Table 21: Learner's Toolkit

<table>
<tr><td colspan="2">Name and type of intervention:
Learner's Toolkit – a 'bolt-on' type study intervention</td></tr>
<tr><td colspan="2">Description of the intervention:
- Intervention occurred across three phases.
- Training interventions developed through 8 units of work: (1) Fighting Forgetting, (2) Building Understanding, (3) Building Good Habits, (4) Desirable Difficulties, (5) Belief and Commitment, (6) Own It, (7) Me and My Future, and (8) Drive the Bus.
- One school timetabled the program/intervention through normal timetable, whilst one school developed a timetable in which the program was delivered outside of normal subjects.
- Teachers required to attend three workshops.
- Toolkit packaged and shared with teachers and students the Microsoft OneNote application.
- The structured program develops a sequential and systematic student instructional training continuum.
- Program supports students to take control of their learning over the remainder of their educational journey.</td></tr>
<tr><td colspan="2">First record (full reference, must contain detailed methods, including details of implementation and evaluation):
Byers, T., Leighton, V., Leggett, J., Krzensk, A., Adamson, R., Pollock, C., & MacMahon, S. (2022). The impact of a preparatory science of learning intervention in secondary schools contexts in Australia [Article]. Review of Education, 10(1), Article e3340. https://doi.org/10.1002/rev3.3340</td></tr>
<tr><td colspan="2">Outcomes measured:
- Relevant domains of Pintrich et al.'s (1991) MSLQ survey used to measure learner beliefs, self-efficacy and task value.
- Students' metacognitive knowledge.
-</td></tr>
<tr><td colspan="2">Strengths:
- Developed and implemented in an Australian context.
- Encourages student autonomy.
- Units build across a continuum.</td></tr>
<tr><td colspan="2">Limitations:
- Time related barriers in an already crowded curriculum.
- Strategies need to be developed into more student-friendly language as opposed to science of learning language.</td></tr>
<tr><td>Adaptions made to original intervention/program:</td><td>Record:</td></tr>
<tr><td>N/A</td><td>N/A</td></tr>
<tr><td colspan="2">Related records: N/A</td></tr>
</table>

Table 22: Mathematical Metacognitive Discourse with IMPROVE

Name and type of intervention
Mathematical metacognitive discourse with IMPROVE

Description of the intervention
Conducted in school classrooms by teachers (with researcher/assistant support/monitoring) over 16 sessions in a four-month period. Focus was a "number sense" problem solving unit. An experimental and control group both received training in mathematical discourse, with the control group discourse focusing on domain-specific knowledge (declarative, explanatory and procedural). The experimental group discourse focus was metacognitive, implemented via the IMPROVE framework. Students were given metacognitive self-question prompts, outlined on a card as a circular framework/path between the three key skills of planning (including problem comprehension, knowledge connection, and strategy), monitoring, and reflection.
Teachers conducted the first introductory session, research assistants the next (double) session to demonstrate and model the discourse program, and then teachers conducted the subsequent 12 sessions, with students completing researcher-supplied worksheets. The last two of these were videotaped, and the subsequent final session was attended by researchers for debriefing and feedback.

First record (full reference, must contain detailed methods, including details of implementation and evaluation):
Shilo, A., & Kramarski, B. (2019). Mathematical-metacognitive discourse: how can it be developed among teachers and their students? Empirical evidence from a videotaped lesson and two case studies [Article]. *ZDM - Mathematics Education*, *51*(4), 625-640. https://doi.org/10.1007/s11858-018-01016-6

Outcomes measured:
Use of metacognitive statements in mathematical discourse
Mathematical problem solving (tests pre- and post- intervention).

Strengths:
Integrated into maths classes; conducted by teachers. Intervention improved students' problem solving abilities.

Limitations:
Domain specific. No investigation of persistence or more general transfer.

Adaptions made to original intervention/program:	**Record:**
Implemented the IMPROVE framework as part of explicit mathematical discourse training; control group received comparable training (ie discourse without metacognitive component) rather than only usual learning.	Kramarski, B., & Mevarech, Z. R. (2003). Enhancing mathematical reasoning in the classroom: The effects of cooperative learning and metacognitive training. *American Educational Research Journal, 40*(1), 281–310. https://doi.org/10.3102/00028 31204 0001281.
As above, this earlier version of the intervention used cooperative learning with IMPROVE, but without explicit training in mathematical discourse.	Kramarski, B. (2004). Making sense of graphs: does metacognitive instruction make a difference on students' mathematical conceptions and alternative conceptions? *Learning and Instruction*, *14*(6), 593-619. https://doi.org/https://doi.org/10.1016/ j.learninstruc.2004.09.003

Related records: N/A

Table 23: Mental Contrasting with Implementation Intentions (MCII)

Name and type of intervention: Mental Contrasting with Implementation Intentions (MCII)	
Description of the intervention Children were taught the MCII technique by a trained "interventionist" in groups of 4-5 via an initial one-hour session and practised it in two further one-hour sessions over a three-week period. They were instructed to visualise and write down (in sequence) - a wish or goal related to schoolwork - the most positive outcome ("one best thing") of fulfilling the goal - an obstacle that could stand in the way of achieving the goal - details of the obstacle (when/where it would occur) - what they could do to overcome the obstacle and then fill out an implementation intention template: "if [obstacle], then [action]".	
First record (full reference, must contain detailed methods, including details of implementation and evaluation): Duckworth, A. L., Kirby, T. A., Gollwitzer, A., & Oettingen, G. (2013). From Fantasy to Action: Mental Contrasting With Implementation Intentions (MCII) Improves Academic Performance in Children [Article]. *Social Psychological and Personality Science*, *4*(6), 745-753. https://doi.org/10.1177/1948550613476307	
Outcomes measured: Grades (GPA), attendance, and conduct	
Strengths: Not domain-specific; simple and relatively quick to implement; could be adapted to any age group; could be conducted by teachers with minimal training required. Could be extended to include ongoing support/reinforcement. Evaluation included control group as well as recording of outcome measures pre- and post-intervention (and at another later time point).	
Limitations: Narrow in scope (one specific visualisation/planning strategy). Positive effects were observed but diminished over time.	
Adaptions made to original intervention/program:	**Record:**
N/A	
Related records: **N/A**	

Table 24: Metacomprehension Training (MCT)

<table>
<tr><td colspan="2">Name and type of intervention:
Metacomprehension training (MCT)</td></tr>
<tr><td colspan="2">Description of the intervention

Selected students were given two 2-hour training sessions per week for five weeks in small groups, by an educational psychologist, during school hours but out of their usual classrooms. Ten fundamental metacomprehension skills were identified and included in the training (for comparison, another group was given training in ten comprehension – not metacomprehension – skills, and a third, control, group followed usual classroom language curriculum). Each training session commenced with a review of material from the previous session. A new activity was then introduced, supported by an activity card, with children encouraged to work independently, flexibly apply the methods presented, use self-correction, etc. The group did not move on to a new task until all students had completed the exercise. Each training session ended with students completing a brief reflection (“What did I learn today?” and “What difficulties did I encounter?”).</td></tr>
<tr><td colspan="2">First record (full reference, must contain detailed methods, including details of implementation and evaluation):
Filippello, P., Tassone, V., Spadaro, L., & Sorrenti, L. (2016). Comparison of the effectiveness of comprehension and meta-comprehension intervention programs in poor comprehenders [Article]. Life Span and Disability, 19(2), 107-130. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85010333013&partnerID=40&md5=6a3cc0d0b1a613c1a94e222c814c882c</td></tr>
<tr><td colspan="2">Outcomes measured:
Reading comprehension and meta-comprehension (metacognitive knowledge and monitoring ability); both pre- and post- intervention.</td></tr>
<tr><td colspan="2">Strengths:
The metacomprehension training was more effective than both the straight comprehension training and the standard curriculum at improving reading comprehension.</td></tr>
<tr><td colspan="2">Limitations:
Trial was limited to participants with identified deficits in both reading comprehension and metacognitive skills. Domain-specific training and outcome measures. Specialised instructor.</td></tr>
<tr><td>Adaptions made to original intervention/program:</td><td>Record:</td></tr>
<tr><td>N/A</td><td></td></tr>
<tr><td colspan="2">Related records:
N/A</td></tr>
</table>

Table 25: Meta-CIC Model

Name and type of intervention: Meta-CIC Model (Collaborating Inquiry Community)
Description of the intervention: The educational intervention includes three major components: a) Baseline curriculum – engaging students in open environmental inquiry projects to study nearby environment. Students studied nearby environment and identified real-life environmental issues related to surroundings. Students developed and studied self-derived questions by following a scientific inquiry process which was comprised of seven stages (see p. 629). Some of the topics included recycling, consumption, environmental hazards, factories and industries. Students worked in pairs. b) Meta component – supporting students' metacognition through explicit environmentally oriented metacognitive guidance. Student knowledge about metacognition supported using Schraw's (1998) *Strategy Evaluation Matrix* (SEM). The Meta-CIC assigned specific strategies of the SEM to each stage of inquiry process. Teachers taught SEM during class sessions with students required to implement strategies to complete tasks throughout various stages of the inquiry process. In addition to the SEM, Schraw's (1998) *Regulatory Checklist* (RC) and Mavarech and Kramarski's (1997) *Reflective Metacognitive Questions* (RMC) were also used. c) CIC component – supporting students' metacognition through peer collaborations. Involved three pairs of students working on different projects who then joined together for a CIC meeting at each stage of the inquiry process. Students followed a macro script for this meeting. Peer feedback took place after each round.
First record (full reference, must contain detailed methods, including details of implementation and evaluation): Adler, I., Zion, M., & Mevarech, Z. R. (2016). The effect of explicit environmentally oriented metacognitive guidance and peer collaboration on students' expressions of environmental literacy [Article]. *Journal of Research in Science Teaching*, *53*(4), 620-663. https://doi.org/10.1002/tea.21272
Outcomes measured: - Environmental literacy (knowledge, attitudes and behaviour) - Domain-independent metacognitive skills - Domain-dependent metacognitive skills
Strengths: - Adaptable to fit with Australian Curriculum. - Student agency in directing their learning. - Inquiry process set out using seven stages. - Inquiry process interspersed with SEM. - Metacognition is able to be embedded in curriculum. - Opportunities for students to participate in collaborative learning.

Limitations:

- Domain specific (Science curriculum).
- Significant time allocated to the inquiry-based project.
- Teachers will need experience with open inquiry-based teaching to deliver.
- Additional workload for teachers as they supported students by providing feedback after school hours via an online asynchronous forum.
- Students who participated in this study were considered as high-achievers and were part of homologous classrooms.
- Lack of pre- and post- assessments of students' metacognition.
- Although the trial was randomised the sample size was not large enough and the statistics applied were not always correct considering the research design. No power calculations were undertaken prior to the study. The process of randomisation was not documented.

Adaptions made to original intervention/program:	**Record:**
N/A	N/A

Related records:

Schraw, G. (1998). Promoting general metacognitive awareness. *Instructional Science*, 26(1–2), 113–125.

NOTE: Schraw (1998) is an original record cited in Alder et al. (2016), but there are extensive adaptations made to the original instrument that it has warranted its own data extraction table.

Table 26: Metacognitive Strategy and Working Memory Training (MetaCogmed)

<table>
<tr><td colspan="2">Name and type of intervention:

Metacognitive strategy and working memory training (MetaCogmed)</td></tr>
<tr><td colspan="2">Description of the intervention
Participants received an intervention consisting of either working memory training (Cogmed) or both working memory and metacognitive strategy training (MetaCogmed) (a third group was an adaptive control group).
Training consisted of 20-25 one-hour sessions over 6-7 weeks; these were conducted as “after school clubs”, run every day at participants’ schools and supervised by the researchers.
In the first 45 minutes of each session, participants completed a set of computerised tasks (for intervention groups, this was the Cogmed working memory training). They then spent 10-15 minutes independently completing a section of a workbook, including reading comprehension exercises and worded maths problems for all participants plus metacognitive training for the MetaCogmed group. The metacognitive workbook component began with reflection exercises, encouraging children to “think about their thinking” as they completed the computerised training tasks, and subsequently introduced planning, monitoring, evaluating, motivating and focusing strategies. These were interspersed with the exercises through the sections of the workbook, initially as questions explicitly prompting children to plan, monitor, etc as they worked on the workbook and computer-based tasks, and later as less explicit prompts. Children were encouraged to think of their own cognitive strategies and document how, when and why to use them in a “Personal Strategy Guide”.
Workbook completion was checked during and after each session by the coaches (researchers).</td></tr>
<tr><td colspan="2">First record (full reference, must contain detailed methods, including details of implementation and evaluation):
Jones, J. S., Milton, F., Mostazir, M., & Adlam, A. R. (2020). The academic outcomes of working memory and metacognitive strategy training in children: a double-blind randomized controlled trial [Journal article]. Developmental science, 23(4), e12870. https://doi.org/10.1111/desc.12870</td></tr>
<tr><td colspan="2">Outcomes measured:
Working memory (four tasks from the AWMA); reading comprehension and mathematical reasoning (respective subtests from the WIAT-II).
All were tested before, immediately after and 3 months after the intervention.</td></tr>
<tr><td colspan="2">Strengths:
Use of adaptive control group to control for expectancy and motivation effects of interventions.
The metacognitive intervention increased the effectiveness of the working memory intervention at improving working memory, and this effect persisted.</td></tr>
<tr><td colspan="2">Limitations:
Large number of withdrawals from program (>20% of intervention groups did not complete training). Metacognitive component of the intervention was not tested alone and the working memory component utilised proprietary software. Domain general but effects were specific; ie positive effects of interventions did not transfer to reading or maths.</td></tr>
<tr><td>Adaptions made to original intervention/program:</td><td>Record:</td></tr>
<tr><td>N/A</td><td></td></tr>
<tr><td colspan="2">Related records: N/A</td></tr>
</table>

Table 27: Metacognition and Meta-Affect Applied to Mathematical Problem Solving

Name and type of intervention:

Metacognition and meta-affect applied to mathematical problem solving

Description of the intervention

Meta-affect regulation and metacognitive regulation via self-question prompts, implemented by maths teachers during usual scheduled lessons on verbal (mathematical) problem solving; two 1-hour sessions each week for five weeks. Prior to intervention, teachers attended a three hour study group. All received training on deeper understanding of serial problems; the teachers for the two intervention groups further received information on self-regulation (planning, monitoring and reflection), and the use of self-questioning prompts for metacognition (or meta-affect) activation. In the classroom sessions, students were explicitly introduced to the self-regulation process and the role of self-questioning. They spent the majority of each session solving serial problems using the processes, ending each time with a discussion of the use of the processes.

First record (full reference, must contain detailed methods, including details of implementation and evaluation):

Tzohar-Rozen, M., & Kramarski, B. (2017). Metacognition and meta-affect in young students: Does it make a difference in mathematical problem solving? [Article]. *Teachers College Record*, *119*(13), Article 130314. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85044384266&partnerID=40&md5=1c3c2cbdd655cc8d0fed148a85896a3f

Outcomes measured:

Mathematical achievement, via verbal problem solving questions (pre- and post-intervention) and a graph interpretation task ("Novel transfer task").

Use of metacognitive and/or meta-affective elements in self-regulated learning processes, via thinking aloud protocols.

Strengths:

Both interventions improved mathematical outcomes, including on the transfer task. Replaced usual classroom problem solving sessions with minimal teacher training. Meta-affective training also increased use of metacognitive strategies.

Limitations:

Quite short-term. No follow-up. Domain specific. Did not investigate further transfer.

Adaptions made to original intervention/program:	**Record:**
This record only considered an affective self-regulated learning intervention compared to a control group; current intervention adds a third group with a distinct metacognitive intervention.	Tzohar-Rozen, M., & Kramarski, B. (2013). How does an affective self-regulation program promote mathematical literacy in young students. *Hellenic Journal of Psychology*, *10*(3), 211-234.
Compared metacognitive and meta-affect interventions, but no control group.	Tzohar-Rozen, M., & Kramarski, B. (2014). Metacognition, motivation and emotions: Contribution of self-regulated learning to solving mathematical problems. *Global Education Review*, *1*(4).

Related records:

N/A

Table 28: Metacognition-Based Reading Intervention Programs

Name and type of intervention: Metacognition-Based Reading Intervention Programs
Description of the intervention: - Intervention programs aimed at developing students' metacognitive strategies in reading comprehension. The intervention program spanned over 15 lessons, with each lesson lasting 45 minutes. - Two different sets of material addressing metacognitive strategies were prepared, one for mathematics, and one for reading. - The strategies targeted and the lessons devoted to each type of strategy are provided in a table. The first six lessons focused on orientation and planning strategies, and the next four on monitoring processes. Two lessons were devoted to fix-up strategies which addressed metacognitive evaluation processes. The final three lessons were devoted to the integration of the previously learnt strategies. - Although there were three clusters of strategies, namely planning, monitoring, and evaluation in both mathematics and reading, the domain-specific characteristics of each subject-matter dictated differentiation of the form and of the sequence of strategies. In reading, the sequence of text anticipation, text maintenance, and fix-up strategies reflected the usual phases of the (meta)cognitive strategies as described in previous sections. In mathematics, the sequence was determined based on data from a previous study, with the first three lessons focusing on interpretation of results of easy word problems that are solved with overly automatized strategies. Thus, orientation strategies were trained through reflection on what the problem requirements were and what was found. - All the training tasks of the intervention program in both mathematics and reading were developed so that they would facilitate the use of metacognitive strategies. In reading, lessons contained (a) "usual" narrative or explanatory texts followed by questions that required reflection on either text characteristics or students' own comprehension processes; (b) document-type texts that might shape students' beliefs about reading in general and about the variety of possible text comprehension phases and processes.
First record (full reference, must contain detailed methods, including details of implementation and evaluation): Csíkos, C., & Steklács, J. (2010). Metacognition-based reading intervention programs among fourth-grade hungarian students. In *Trends and Prospects in Metacognition Research* (pp. 345-366). https://doi.org/10.1007/978-1-4419-6546-2_16
Outcomes measured: - Meta-level of strategy use in reading.
Strengths: - Embedded in classroom lessons. - Integrative approach to instructional practices. - Focuses on strategies that are genre-free.

<table>
<tr><td colspan="2">Limitations:
-
-</td></tr>
<tr><td>Adaptions made to original intervention/program:</td><td>Record:</td></tr>
<tr><td>N/A</td><td>N/A</td></tr>
<tr><td colspan="2">Related records:
N/A</td></tr>
</table>

Table 29: Metacognitive Engagement

<table>
<tr><td colspan="2">Name and type of intervention:
Metacognitive Engagement</td></tr>
<tr><td colspan="2">Description of the intervention:
- In groups of three or four, students worked collaboratively on novel problems while at the amusement park and during subsequent classroom tasks.
- The amusement park problem set was developed by a high school physics teacher.
- The problem set contains problems that are hands-on and minds-on and use the physical experience of the rides at the park to complement the kinematics units of the physics curriculum. The experiential nature of the problems makes them novel and thus an ideal context for studying students' engagement with their own learning.
- Sample questions from the workbook that the students completed during the field trip are found in Appendix B.
- After the amusement park visit, a classroom activity was used to both follow up and elaborate the amusement park encounters (see Appendix C for the Grade 12 version).
- The activities were specifically designed to extend students' experiences from the amusement park and other background knowledge.
- The problems were similar to the ones that they had encountered on the day of the field trip, but challenged them to think and process information more deeply.</td></tr>
<tr><td colspan="2">First record (full reference, must contain detailed methods, including details of implementation and evaluation):
Nielsen, W. S., Nashon, S., & Anderson, D. (2009). Metacognitive engagement during field-trip experiences: A case study of students in an amusement park physics program. Journal of Research in Science Teaching, 46(3), 265-288. https://doi.org/10.1002/tea.20266</td></tr>
<tr><td colspan="2">Outcomes measured:
- Metacognitive profiles of student behaviours including individual metacognitive engagement</td></tr>
<tr><td colspan="2">Strengths:
- Experiences allow students to consolidate knowledge and develop deeper understandings of kinematics concepts.
- Out-of-school context supports experiential learning.</td></tr>
<tr><td colspan="2">Limitations:
- Access to an amusement park.
- Discipline specific: Physics (Year 11 and 12).
- Small participant group (n=14).
- Would need to determine if this would fit with SACE Stage 1 and/or 2 Physics curriculum and performance standards.</td></tr>
<tr><td>Adaptions made to original intervention/program:</td><td>Record:</td></tr>
<tr><td>N/A</td><td>N/A</td></tr>
<tr><td colspan="2">Related records: N/A</td></tr>
</table>

Table 30: Metacognitive Monitoring and Control

<table>
<tr><td colspan="2">Name and type of intervention:
Metacognitive monitoring and control</td></tr>
<tr><td colspan="2">Description of the intervention
Three parts: training in metacognitive skills for the children, their kindergarten teachers, and their parents. (Different groups received different combinations of child, parent and teacher training.)
Parents and teachers received (as separate groups) three 90-minute sessions over three weeks; multilevel approach including
- metacognitive processes and strategies in order to act as a role model in executing tasks and engaging in learning;
- strategies to support children’s metacognitive competencies.

Children received ten 45-minute sessions (two per week), aimed at teaching them to apply self-regulated and metacognitive learning strategies. Trainers provided progressively less direct instructions over the training period, with the aim of the children using the strategies more autonomously. The training sessions comprised a greeting, an introduction of the subject and strategy, and then its application in a playful manner.</td></tr>
<tr><td colspan="2">First record (full reference, must contain detailed methods, including details of implementation and evaluation):
Dörr, L., & Perels, F. (2019). Improving metacognitive abilities as an important prerequisite for self-regulated learning in preschool children [Article]. International Electronic Journal of Elementary Education, 11(5), 449-459. https://doi.org/10.26822/iejee.2019553341</td></tr>
<tr><td colspan="2">Outcomes measured:
Metacognition, measured by researchers’ observation of participants’ problem-solving behaviour when completing two (physical) geometric reconstruction tasks (“the train track task”), specifically their application of
- monitoring;
- control;
- monitoring and control.

Performance, measured by the correctness of the solution to the above task.</td></tr>
<tr><td colspan="2">Strengths:
The three-pronged training approach – training caregivers and parents to support the children in developing the skills. General meta-cognitive strategies, not domain-specific.</td></tr>
<tr><td colspan="2">Limitations:
Outcomes (use of metacognitive strategies) measured by researcher observation – children may be using them but not vocalising. Lack of suitable instruments for this age group to determine effectiveness of intervention.</td></tr>
<tr><td>Adaptions made to original intervention/program:</td><td>Record:</td></tr>
<tr><td>N/A</td><td></td></tr>
<tr><td colspan="2">Related records:
N/A</td></tr>
</table>

Table 31: Metacognitive Reading Strategy Training

Name and type of intervention: Metacognitive Reading Strategy Training	
Description of the intervention: - Program promotes initial awareness raising, practice, scaffolding and evaluation. - Reading strategies consist of: (1) activate previous knowledge, (2) predict what the text is about, (3) observe the text structure, (4) observe text type and (5) guess from the text. - Training started with the researcher raising student awareness by explaining the strategy explicitly. Explanation included a practical demonstration of effectiveness of strategy, when and how it can be used etc. During the second stage, participants worked on different tasks to practice the strategy and understand effectiveness. Tasks are designed to be carried out individually, in pairs or in groups. The tasks were designed so that participants initially applied the strategies with scaffolded support and then, gradual removal of the scaffolding under the supervision of the researcher. Finally, the researcher provided feedback and participants filled in a “learning diary” to complete the metacognitive part of the training.	
First record (full reference, must contain detailed methods, including details of implementation and evaluation): Martínez, A. G., & De Zarobe, Y. R. (2017). Comparing the benefits of a metacognitive reading strategy instruction programme between CLIL and EFL primary school students. *Elia*, *17*, 71-92. https://doi.org/10.12795/elia.2017.i17.04	
Outcomes measured: - Metacognitive reading strategies	
Strengths: - Flexibility in mode of delivery, i.e., can be used individually, in pairs or with groups of students. - Utilises modelling of strategies. - Improves learners’ reading competence. - Supports students to become independent learners and to monitor own progress.	
Limitations: -	
Adaptions made to original intervention/program:	**Record:**
N/A	N/A
Related records:	

Table 32: Metacognitive Scientific Reconstruction (MSR)

Name and type of intervention: Metacognitive Scientific Reconstruction (MSR)	
Description of the intervention: - All the teachers in the study participated in an in-service teacher-training course (INSET) of 20 hours, prior to the implementation. - Focus was put on the MSR activities, in which teachers were encouraged to discuss different possibilities of describing scientific thinking-routes, with the terms "observation", "hypothesis" and "conclusions". - It was emphasised that whether an idea expresses an observation, a hypothesis or a conclusion, is dependent in many cases on the context, and that scientists themselves sometimes disagree about such methodological issues. Using this context, the constructivist and social-constructivist teaching methods were emphasised.	
First record (full reference, must contain detailed methods, including details of implementation and evaluation): Orion, N., & Kali, Y. (2005). The effect of an earth-science learning program on students' scientific thinking skills. *Journal of Geoscience Education*, *53*(4), 387-393. https://doi.org/10.5408/1089-9995-53.4.387	
Outcomes measured: - Scientific thinking skills	
Strengths: - Scalable intervention.	
Limitations: - Some degree of reliability on teachers' responsiveness to innovative teaching pedagogies. - Domain specific.	
Adaptions made to original intervention/program:	**Record:**
N/A	N/A
Related records: N/A	

Table 33: Metacognitive Strategies

Name and type of intervention:
Metacognitive Strategies

Description of the intervention:

- Several interventions were employed including providing students with focused outcomes, organising collaborative activities and enhancing their skills in reading scientific text, and drawing concept maps during classroom instruction. The interventions were conducted over six weeks totalling 33.3 hours of curriculum time.
- Students were given clearly written focused outcomes at the beginning of the topic and were instructed to attach them in their workbooks at the start of the topic in this study. Students were also given key words or concepts at the beginning of the topic. The researcher always instructed the students to mark off the outcomes covered after a lesson was conducted. Students were encouraged to use the focused outcomes as a checklist when preparing for a test and also to find the meanings of the key words in the topic.
- Collaborative group activities were conducted in the theoretical or practical lessons (when doing experiments) at least once a week. Students were encouraged to discuss phenomena without writing down their ideas. During experiments students were instructed to take turns to set up the equipment and make observations in their experiments while discussing their inferences. Verbal thinking was encouraged during group discussions.
- Concept maps were used at the end of the topic to make connections between key words in the topic. Students were encouraged to use the key words provided at the beginning of each topic to construct concept maps. Students were reminded that there were many ways to construct concept maps and that this was a useful tool to summarise the major concepts in a topic and revise for a science test.
- Students were often given texts to read followed by answering questions. They were encouraged to skim through the text first followed by reading slowly and underlining or highlighting major concepts, make summaries in their own words and write out questions next to relevant texts (adjunct questioning). In some instances, student were given summary notes related to text, with gaps to fill in.

First record (full reference, must contain detailed methods, including details of implementation and evaluation):
Wagaba, F., Treagust, D. F., Chandrasegaran, A. L., & Won, M. (2016). Using metacognitive strategies in teaching to facilitate understanding of light concepts among year 9 students. *Research in Science and Technological Education*, *34*(3), 253-272. https://doi.org/10.1080/02635143.2016.1144051

Outcomes measured:

- Metacognitive strategies
- Metacognitive demand
- Students' understanding of concepts of light

Strengths:	
- Trialled in an Australian school contexts. - Aligns with the Australian Curriculum.	
Limitations:	
- Only trialled in one class of Year 9s in an Australian school (*n*=35). - Domain specific. - Findings suggest no significant gains made in students' metacognitive strategies.	
Adaptions made to original intervention/program:	**Record:**
N/A	N/A
Related records:	
N/A	

Table 34: Metacognitive Support for Intelligent Tutoring

Name and type of intervention:
Metacognitive support for intelligent tutoring

Description of the intervention
Implemented as a cue card providing "metacognitive support" to students solving geometry problems in a computer-based learning environment (CBLE). Single 90-minute intervention.
Students were provided with an initial introduction to the CBLE (via two problems in a different topic), and completed a pre-test in the CBLE. They were then provided with text containing relevant topic information (four geometry principles). Half of participants then received the metacognitive support cue card and all worked through a CBLE geometry lesson. The cue cards were divided into two sections, each with three hints/prompts.

- First section, "How do I solve the problem?": questions prompting a structured approach to solving the problem; ie identifying the relevant information in the text and diagrams and combining it together.
- Second section, "What do I do when I get stuck?": aimed to support monitoring and self-regulation during problem solving by providing specific information about the help tools, ie in which situation to use each one.

First record (full reference, must contain detailed methods, including details of implementation and evaluation):
Schwonke, R., Ertelt, A., Otieno, C., Renkl, A., Aleven, V., & Salden, R. J. C. M. (2013). Metacognitive support promotes an effective use of instructional resources in intelligent tutoring. *Learning and Instruction*, *23*, 136-150.
https://doi.org/https://doi.org/10.1016/j.learninstruc.2012.08.003

Outcomes measured:

- Procedural and conceptual knowledge transfer (geometry). Pre-intervention via solving problems within CBLE (without hints); post-intervention via problem solving on paper.
- Learning time and use of help tools. Measured via CBLE log-files and eye-tracking: duration and frequency data for problem information (statements and diagrams) and tool use (overview table, glossary, hints).

Strengths:
The metacognitive support assisted students with low-prior knowledge to gain conceptual understanding and reduced time required to work through the tasks. Little training/preparation or resources required to implement.

Limitations:
Domain specific. The "far transfer" tested was still within the specific domain (geometry). Very brief (one 90 minute class).

Adaptions made to original intervention/program:	**Record:**
N/A	

Related records:
N/A

Table 35: Mind Mapping

Name and type of intervention: Mind Mapping (as a meta-learning strategy)
Description of the intervention: - Mind map-training was used as the basis for the development of two strategy instruction programs. Both programs include 10 lessons of 50 minutes each, spread over 10 consecutive weeks, and share a general structure. In the first lesson, students were explicitly introduced to essential mind map characteristics (e.g., radial structure, colour use, dimension) and their importance in processing and learning informative texts. - Lesson 2–9 were devoted to the gradual instruction, practice, and application of specific text-learning strategies, supporting the essential text-learning processes, by means of four sequentially ordered learning techniques i.e., (1) scanning the text, reading the text and clarifying incomprehension ('getting an over- view'), (2) identifying key information by highlighting relevant key words, sub-ideas, and supporting details in different colours ('text organisation'-strategy), (3) active manipulation of the text mate- rial by means of mind map assignments ('text transformation'- strategy), and (4) reviewing the process and product outcomes. This strategy instruction can be regarded as a multicomponent instruction as the intervention included instruction in various text-learning strategies. The tenth and final lesson was spent on explicitly addressing the transfer of mind mapping in multiple content areas (e.g., writing, mathematics, French). - Informative texts used in both experimental conditions were identical and derived from students' grade-specific social studies and science textbooks. Texts were provided for fifth and sixth grade, addressing their grade-specific subject-matter on nature (e.g., animals in fifth grade, ecology in sixth grade), history (e.g., World War I in fifth grade and armistice in sixth grade), and society (e.g., the town council in fifth grade and country's governance in sixth grade). As lessons progressed, structural clues and signalling devices in the informative texts (e.g., subheadings, words printed in italics or boldface indicating or emphasizing text structure) were gradually omitted, to induce students' independent selection and organization processes. On the basis of prior research and elementary school teachers' suggestions, these texts were previously evaluated and adjusted as to their length, difficulty, clarity, content, and organisation. - A scoring rubric for the mind maps is included as Appendix B.
First record (full reference, must contain detailed methods, including details of implementation and evaluation): Merchie, E., & Van Keer, H. (2016). Mind mapping as a meta-learning strategy: Stimulating pre-adolescents' text-learning strategies and performance? *Contemporary Educational Psychology*, *46*, 128-147. https://doi.org/10.1016/j.cedpsych.2016.05.005
Outcomes measured: - Students' independent cognitive and metacognitive text-learning strategy use.
Strengths: - Can be used across various subject domains. - Suitable for a school/classroom in terms of time allocation. - Induces and stimulates deep-level text-learning strategy use. - Scalable

<table>
<tr><td colspan="2">Limitations:
- Time for assessing individually generated mind maps.</td></tr>
<tr><td>Adaptions made to original intervention/program:</td><td>Record:</td></tr>
<tr><td>N/A</td><td>N/A</td></tr>
<tr><td colspan="2">Related records:
N/A</td></tr>
</table>

Table 36: Motivational Metacognitive Model (MM)

Name and type of intervention: Motivational Metacognitive Model (MM)	
Description of the intervention Applied to grade five students with identified sociocultural disadvantage. The eight participating schools were divided into two groups; students in one group received a preventative SO/RC (Structural Organisational/Centred on Resilience) intervention and the other the Motivational Metacognitive (MM) intervention. The interventions were implemented by teachers over the course of one school year. Teachers received 100 hours of training prior to the start of the school year. For the MM intervention, "teachers learned metacognitive teaching methods aimed at increasing their sense of self-efficacy and problem-solving skills as well as the awareness of their own learning processes". Teachers further took part in monitoring and discussion meetings every 15 days throughout the intervention, "aimed at ensuring optimal application" of the intervention models.	
First record (full reference, must contain detailed methods, including details of implementation and evaluation): Frolli, A., Ricci, M. C., Rizzo, S., Di Carmine, F., Rega, A., Savarese, G., & Franzese, L. (2021). The effectiveness of the metacognitive model with children in disadvantaged conditions [Journal article]. *Current Paediatric Research*, *25*(10), 973-975. https://www.cochranelibrary.com/central/doi/10.1002/central/CN-02346841/full	
Outcomes measured: - Reading speed, accuracy and comprehension (MT tests); - calculation speed and accuracy (AC-MT tests); - writing and spelling (BVSCO); - school self-efficacy via a multidimensional self-esteem test (TMA); All tested before and after the intervention (i.e. at the start and end of grade 5).	
Strengths: Domain non-specific; undertaken by teachers and integrated into usual classroom teaching; varied outcomes were measured and all showed positive improvement.	
Limitations: Small sample size; lengthy teacher training time; no follow-up to see if benefits persisted.	
Adaptions made to original intervention/program:	**Record:**
N/A	
Related records: N/A	

Table 37: Modified Solve It! Problem Solving Strategy Instruction

<table>
<tr><td colspan="2">Name and type of intervention: Modified Solve It! Problem solving strategy instruction</td></tr>
<tr><td colspan="2">Description of the intervention
Intervention was conducted by teachers and incorporated into usual (50-minute) mathematics classes in schools from the start of the school year for approx. 6 months. Teachers received training over the summer break. The intervention consisted of six initial explicit instruction sessions (run on consecutive school days), followed by weekly practice sessions (12-16 in total) in which students applied the strategies to worded maths problems, initially working in groups and then later independently. Teachers were provided with scripts for the instructional and practice sessions, class charts of the process, and student cue cards.

The problem-solving process taught to students comprised seven explicit steps: read, paraphrase, visualise, hypothesise, estimate, compute, and check. The metacognitive component(s) of the process were formulated as “say, ask, and check”, and students were taught to incorporate these in every step of the process via the use of prompts (e.g., from student cue cards, “Ask: Have I read and understood the problem”, “Check: The picture against the problem information”).

NB Intervention was applied to all students in selected classes/schools, but data was analysed only for those with either “average” or “low” previous maths achievement and no disability, or those with low previous achievement and a learning disability.</td></tr>
<tr><td colspan="2">First record (full reference, must contain detailed methods, including details of implementation and evaluation):
Krawec, J., & Huang, J. (2017). Modifying a Research-Based Problem-Solving Intervention to Improve the Problem-Solving Performance of Fifth and Sixth Graders with and without Learning Disabilities [Article]. Journal of Learning Disabilities, 50(4), 468-480.
https://doi.org/10.1177/0022219416645565</td></tr>
<tr><td colspan="2">Outcomes measured:
Curriculum-based measures (CBMs) of mathematical problem solving (researcher-developed). Administered prior to the intervention and then another four times after the intervention.</td></tr>
<tr><td colspan="2">Strengths:
Conducted by teachers, replacing usual maths class; teacher feedback was generally positive.
Explicitly incorporated metacognitive component into all steps of problem-solving strategy.
Intervention group initially improved problem-solving performance at higher rate than control group.</td></tr>
<tr><td colspan="2">Limitations:
Domain-specific. Length of teacher training not mentioned.
Not possible to isolate/determine effect of metacognitive component of intervention.
Over a longer time period, improvement of treatment group was at similar rate to control.
Transfer of skills not investigated.</td></tr>
<tr><td>Adaptions made to original intervention/program:</td><td>Record:</td></tr>
<tr><td>Initial instruction sessions extended from 3 to 6 days to add conceptual content for lower age group and teach other content more explicitly. In particular, metacognitive components expanded and made more explicit. Visual supports added.</td><td>Montague, M. (2003). Solve it! A mathematical problem-solving instructional program. Reston, VA: Exceptional Innovations. Error! Hyperlink reference not valid.</td></tr>
<tr><td colspan="2">Related records: N/A</td></tr>
</table>

Table 38: Nexxo-Training

<table>
<tr><td colspan="2">Name and type of intervention:
Nexxo-Training</td></tr>
<tr><td colspan="2">Description of the intervention:

- The Nexxo application is based on neuropsychological tasks known as “go/no-go” and “stop signal” tasks. These tasks involve sup- pression of an on-going response (inhibition), and alertness by training vigilance, in which changes were to be detected when only a low rate of relevant stimuli was presented. The game had two different blocks. In the vigilance block, the user had to tap the screen sporadically (discriminating between possible distractors and thus maintaining a state of alertness, known as “vigilance”). In the inhibition block, the user must tap very frequently (holding back an automatic response, known as “inhibition or self-control”). The mechanics of the game included requirements to press the screen in the presence of a specific stimulus, for example: “tap when you see something edible”.
- In the vigilance block, the rate of target presence was less than 30% (70% no-go probability), whereas, in the inhibition block, the rate of target presence was more than 70% (30% no-go probability). The instructions and stimuli were changed from game to game.
- The whole Nexxo-training nature and structure (tasks), administration, and dose/duration details can be seen in Supplemental material.</td></tr>
<tr><td colspan="2">First record (full reference, must contain detailed methods, including details of implementation and evaluation):
Rossignoli-Palomeque, T., Perez-Hernandez, E., & González-Marqués, J. (2020). Training effects of attention and EF strategy-based training "Nexxo" in school-age students. Acta Psychologica, 210, 103174. https://doi.org/10.1016/j.actpsy.2020.103174</td></tr>
<tr><td colspan="2">Outcomes measured:
- Attention and executive functions (EF)</td></tr>
<tr><td colspan="2">Strengths:
- Game like structure of app would appeal to early years students.
- Results indicate improved attention and EF for students in the 3rd grade (8-9 years)</td></tr>
<tr><td colspan="2">Limitations:
- May not be suitable for students aged 6 to 7 years.
- Only trialled with monolingual students.</td></tr>
<tr><td>Adaptions made to original intervention/program:</td><td>Record:</td></tr>
<tr><td>N/A</td><td>N/A</td></tr>
<tr><td colspan="2">Related records:
N/A</td></tr>
</table>

Table 39: Non-Instructional Prosocial Intervention

Name and type of intervention:
Non-instructional prosocial intervention

Description of the intervention
Non-instructional prosocial intervention conducted over 10 weeks in two primary school classes. The intervention begun with the researcher giving each class a ten-minute explanation of the tasks. Teachers were separately provided with an outline of the intervention (but not its goals). Teachers' participation was limited to providing daily reminders to the class to complete the activities. These were:

- planning: filling in a worksheet at the start of each week, setting a goal for helping others;
- acting: throughout each week, enacting their prosocial behaviour goals (how and whenever they chose);
- evaluation: filling in a worksheet at the middle and end of each week, evaluating their goals and behaviour.

First record (full reference, must contain detailed methods, including details of implementation and evaluation):
Umino, A., & Dammeyer, J. (2016). Effects of a non-instructional prosocial intervention program on children's metacognition skills and quality of life. *International Journal of Educational Research*, *78*, 24-31. https://doi.org/https://doi.org/10.1016/j.ijer.2016.05.004

Outcomes measured:

- Metacognitive knowledge and regulation (via a Danish translation of Metacognitive Awareness Inventory MAI)
- Health-related quality of life (QoL) (via Kid-KINDL, Danish version)

(both pre- and post-intervention)

Strengths:
Simple implementation with little dedicated class time required and minimal teacher training/input. Improved boys' metacognitive awareness, overall QoL, and self-esteem.

Limitations:
No control group. No significant effect of intervention on metacognition or QoL was found for girls, but no mention is made of pre-intervention gender differences.

Adaptions made to original intervention/program:	**Record:**
N/A	

Related records:

N/A

Table 40: Offline Metacognition

Name and type of intervention: Offline Metacognition	
Description of the intervention: - Five instruction variants that worked cumulatively. - Metacognitive skills for the development of mathematical problem solving. - Trained students in prediction (Pr), number reading (NR), procedural calculation (P), language-related (L) and mental-representation (M). - Selected evaluation (Ev), relevance (R) and number sense (N) to measure transfer. - A pre-test – intervention – post-test-follow-up design with control groups. - Intervention took place in small groups (of about 10 children) in separate classrooms five times in two weeks for 50 minutes each time. Each session consisted of the mathematics problems in accordance with the instructions given in the program. The metacognitive experimental group (Number Town) was compared with four other instruction variants. In the metacognitive (Number Town) and cognitive (Count City) training, NR, P, M and L skills were explicitly taught as trained cognitive content. In the motivation and math conditions, children also completed exercise on these NR, P, M and L tasks, without the tasks being in accordance with our conceptual framework. Moreover, Pr was explicitly taught in the metacognitive group. None of the five training sessions worked on tasks dealing with R or N. - Each of the metacognitive sessions involved a direct Pr strategy as well as a direct cognitive (NR, P, L and M) instruction. - The metacognitive training was verbal in nature and focused on prediction of task difficulty as well as on the tasks and problem-solving procedures themselves. - Each session in the metacognitive condition started with an orientation or rehearsal phase. - During the two week period of the treatment manipulation, the students did not receive any metacognitive strategy instruction from their regular classroom teacher.	
First record (full reference, must contain detailed methods, including details of implementation and evaluation): Desoete, A., Roeyers, H., & De Clercq, A. (2003). Can offline metacognition enhance mathematical problem solving? [Article]. *Journal of Educational Psychology*, *95*(1), 188-200. https://doi.org/10.1037/0022-0663.95.1.188	
Outcomes measured: - Pre- and post-test measures for domain-specific knowledge and skills	
Strengths: - Can be delivered by SSOs (support staff) after 10 hours of training. - Can be delivered to small groups of 10 students at a time.	
Limitations: - Relies on students' abilities to comprehend verbal instructions.	
Adaptions made to original intervention/program:	**Record:**
N/A	N/A
Related records: N/A	

Table 41: Online Discussion with IMPROVE

<table>
<tr><td colspan="2">Name and type of intervention:
Online discussion with IMPROVE</td></tr>
<tr><td colspan="2">Description of the intervention
The intervention replaced usual mathematics classes (five 45-minute sessions per week) for four weeks. Four groups each received a different treatment: (a) online discussion embedded within metacognitive guidance Online+Meta), (b) online discussion with no metacognitive guidance (Online), (c) face-to-face discussion embedded with metacognitive guidance (Ftf+Meta), and (d) face-to-face discussion with no metacognitive guidance (Ftf). All lessons begun with teacher introductions to the topics/tasks, including explaining and modelling strategies, and ended with the teacher reviewing the lesson; in between, students worked cooperatively on problems for 45 minutes. One class each week was conducted in a computer laboratory. The metacognitive guidance was delivered according to the IMPROVE framework. Students in the online discussion groups received access to an online discussion forum, within which they accessed and completed tasks, and engaged in discussion with peers. Students could access the forum within and outsuide of school hours and thus had extra flexibility in when they could work on, discuss, and submit tasks. Teachers monitored forums but did not participate in online discussions.</td></tr>
<tr><td colspan="2">First record (full reference, must contain detailed methods, including details of implementation and evaluation):
Kramarski, B., & Mizrachi, N. (2006). Online Discussion and Self-Regulated Learning: Effects of Instructional Methods on Mathematical Literacy. The Journal of Educational Research, 99(4), 218-231. https://doi.org/10.3200/JOER.99.4.218-231</td></tr>
<tr><td colspan="2">Outcomes measured:
Mathematical literacy – via a pencil and paper problem solving test, both pre- and post-intervention and an additional task for online groups, administered during online discussion.
Self regulated learning, via questionnaire pre- and post- intervention.</td></tr>
<tr><td colspan="2">Strengths:
Both groups receiving the metacognitive component improved more in mathematical literacy and SRL measures than the non-metacognitive groups. Use of online discussion to support intervention was found to be effective.</td></tr>
<tr><td colspan="2">Limitations:
Domain specific. Short duration. Persistence not investigated. Resources required to monitor/moderate online discussion forums available out of hours not discussed.</td></tr>
<tr><td>Adaptions made to original intervention/program:</td><td>Record:</td></tr>
<tr><td>Added online discussion component to IMPROVE and compared with face-to-face discussion.</td><td>Kramarski, B., & Mevarech, Z. R. (2003). Enhancing mathematical reasoning in the classroom: Effects of cooperative learning and metacognitive training. American Educational Research Journal, 40, 281–310.</td></tr>
<tr><td colspan="2">Related records:
N/A</td></tr>
</table>

Table 42: Strategy-Based Instruction (SBI)

Name and type of intervention:

Strategy-based instruction (SBI)

Description of the intervention

Two phases of intervention:

(i) initial four months: strategy-based instruction, integrated into usual classroom lessons in a foreign language (German);

(ii) subsequent four months: continuing SBI in the German class, along with explicit reinforcement of the SBI in participants' English (native language) class.

Focuses of the SBI included

- planning writing;
- developing problem-solving strategies;
- checking and reviewing writing;
- reflecting on personal learning strategies and approaches.

First record (full reference, must contain detailed methods, including details of implementation and evaluation):

Forbes, K., & Fisher, L. (2020). Strategy development and cross-linguistic transfer in foreign and first language writing [Article]. *Applied Linguistics Review*, *11*(2), 311-339. https://doi.org/10.1515/applirev-2018-0008

Outcomes measured:

Participants completed writing tasks on task strategy and evaluation sheets prior to the intervention, and after each of the first and second phases. The intervention group completed the writing task sheets in each of English, German and French, and a control group in English and German.

From these, use of the four meta-cognitive writing strategies - planning, monitoring, error-correction and self-evaluation – was evaluated, along with the extent to which these were transferred from their initial language of instruction to another language (foreign or native).

Strengths:

Incorporated into usual classroom lessons; metacognitive skills (particularly in use of strategies and error-correction) improved and were transferred from one setting (language) to another.

Limitations:

Domain-specific (foreign language learning). Evaluation relied on students self-reporting of strategies used.

Adaptions made to original intervention/program:	**Record:**
N/A	

Related records:

N/A

Table 43: Schema-Based Instruction (SBI)

Name and type of intervention: Schema-based instruction (SBI)	
Description of the intervention The schema-based instruction (SBI) program comprised four key components: - identifying the structure of problems; - using visual representations of problems (schematic diagrams); - explicit problem solving strategies, including metacognitive strategies of monitoring and reflecting during each stage of the problem solving process; - identifying different ways of solving problems (procedural flexibility) and selecting appropriately. This implementation of SBI was designed to improve students' proportional reasoning. Following 16 hours of training, teachers delivered the SBI intervention via 21 classroom lessons over a 6 week period, covering the same content but replacing the usual classroom delivery for two units of the mathematics curriculum (ratio/proportion and percent). Intervention teachers were further provided with detailed teacher guides, teacher materials and student materials.	
First record (full reference, must contain detailed methods, including details of implementation and evaluation): Jitendra, A. K., Harwell, M. R., Dupuis, D. N., Karl, S. R., Lein, A. E., Simonson, G., & Slater, S. C. (2015). Effects of a research-based intervention to improve seventh-grade students' proportional problem solving: A cluster randomized trial [Article]. *Journal of Educational Psychology*, *107*(4), 1019-1034. https://doi.org/10.1037/edu0000039	
Outcomes measured: PPS test – testing specifically the intervention topics of proportion, ratio and percentage GMADE (Process and applications subtest) - testing general problem solving Both were conducted pre- and post-intervention (two post-tests: at the end of the intervention and after a nine-week interval).	
Strengths: Conducted by teachers, replaced usual classroom lessons in standard topics, large sample size, included control group, included demographic variables in model, good results in specific area of instruction, improvement persisted in short-term.	
Limitations: Multi-component intervention (not only metacognitive), very domain-specific (I.e., specific topics in maths), skills did not appear to transfer (i.e. no improvement on general problem solving over control group).	
Adaptions made to original intervention/program:	**Record:**
Original intervention. Subsequently adapted (see below – Jitendra et al 2013) to include more topics, more student-instruction time, longer teacher-training, larger sample size (more schools and students), reduced involvement of research team, and monitoring of implementation (to improve fidelity across different schools and teachers).	Yan Ping Xin, Jitendra, A. K., & Deatline-Buchman, A. (2005). Effects of Mathematical Word Problem—Solving Instruction on Middle School Students with Learning Problems. The Journal of Special Education, 39(3), 181–192. https://doi.org/10.1177/00224669050390030501
Current study (Jitendra et al 2015) further reduced involvement of research team in implementation, increased size and demographic diversity of sample (student and	Jitendra, A. K., Star, J. R., Dupuis, D. N., & Rodriguez, M. C. (2013). Effectiveness of Schema-Based Instruction for Improving Seventh-Grade Students' Proportional

school-level), included demographic factors in analysis, and improved randomisation.	Reasoning: A Randomized Experiment. *Journal of Research on Educational Effectiveness*, *6*(2), 114-136. https://doi.org/10.1080/19345747.2012.725804
Related records: N/A	

Table 44: Self-Regulation for Threshold Learning

<table>
<tr><td colspan="2">Name and type of intervention:
Self-regulation for threshold learning</td></tr>
<tr><td colspan="2">Description of the intervention
Prior to the intervention, researchers conducted a one-hour structured discussion with students and their teachers, aiming to identify subject areas and topics that students found “troublesome and tricky”, via relaxed group discussion and anonymous written submissions. In consultation with teachers, the student feedback was used to decide the “threshold concepts” that formed the specific learning content for the project. Researchers prepared the academic materials and exercises, which were the same for all groups.
Intervention groups consisting of 12-18 students received a 2-3 hour workshop each week for ten weeks, facilitated by researchers. The first hour of each workshop was focused on exercises and group discussions aimed at improving self-regulation, with exercises introduced in the earlier sessions and then practised/applied. Students spent the rest of each workshop working on mathematical problems, self-pacing, but with an explicit goal of progressing through problems to challenge themselves, with “success” deemed to be attempting personally challenging problems.
Control groups, of a similar size, had similarly structured sessions, but the instructional content was “traditional study skills” such as effective note taking, mnemonics, and revision strategies.
The metacognitive strategies and exercises included:
- goal setting, identifying action steps and potential obstacles, goal refining;
- encouragement to “fail harder”; framing of success as effort and self-reflection rather than outcomes;
- self-reflection via free journalling;
- written self-affirmations.</td></tr>
<tr><td colspan="2">First record (full reference, must contain detailed methods, including details of implementation and evaluation):
Maloney, D. M., Ryan, A., & Ryan, D. (2021). Developing Self-Regulation Skills in Second Level Students Engaged in Threshold Learning: Results of a Pilot Study in Ireland. Contemporary School Psychology, 25(1), 109-123. https://doi.org/10.1007/s40688-019-00254-z</td></tr>
<tr><td colspan="2">Outcomes measured:
Self-regulation; specifically (i) cognitive self-affirmation inclination, (ii) action/state orientation, (iii) self-esteem. (All tested pre and post intervention.)</td></tr>
<tr><td colspan="2">Strengths:
Domain general. Active (rather than business as usual) control group. A range of metacognitive strategies used. Intervention group improved on all three measures of self-regulation while control was stable (group differences significant for measures (i) and (ii)).</td></tr>
<tr><td colspan="2">Limitations:
No test of persistence. Only tested effects on self-regulation and not how benefits potentially transferred to other domains (e.g., the maths that was the focus of the intervention).
Scope/application limited by need to fit ten 2-3 hour workshops into school timetable – i.e., within school hours but not incorporated into usual classes/curriculum; conducted by researchers not teachers. Not randomised and control group much smaller than intervention group.</td></tr>
<tr><td>Adaptions made to original intervention/program:</td><td>Record:</td></tr>
<tr><td>N/A</td><td></td></tr>
<tr><td colspan="2">Related records:
N/A</td></tr>
</table>

Table 45: Social Skill Training – Revised (MASST-R)

<table>
<tr><td colspan="2">Name and type of intervention:
Social Skill Training – Revised (MASST-R)</td></tr>
<tr><td colspan="2">Description of the intervention:
- Intervention designed for students identified as being at-risk (i.e., students who did not feel involved or engaged in a typical/mainstream secondary school program).
- MASST-R is organized around a series of interactive social emotional learning (SEL) modules.
- The modules include (a) Self-Awareness, (b) Social Awareness, (c) Self-Management, (d) Relationship Skills, and (e) Responsible Decision Making. Each lesson follows a structured teaching model of awareness, direct instruction, guided practice, independent practice, and evaluation. As tools for the facilitator, there is a teaching lesson plan, as well as a fully scripted guide. MASST-R contains several features, including journals and graphic organizers that are designed to assist the facilitator and to benefit the students.</td></tr>
<tr><td colspan="2">First record (full reference, must contain detailed methods, including details of implementation and evaluation):
Whetstone, P. J., Gillmor, S. C., & Schuster, J. G. (2015). Effects of a Metacognitive Social Skill Intervention in a Rural Setting with At-Risk Adolescents [Article]. Rural Special Education Quarterly, 34(2), 25-35. https://doi.org/10.1177/875687051503400205</td></tr>
<tr><td colspan="2">Outcomes measured:
- Student’s ability to cope with changes in the school environment
- Self-regulation
- Self-awareness</td></tr>
<tr><td colspan="2">Strengths:
- Significant changes in participants’ behaviours, signalling a rise in more socially appropriate behaviours and decreases in negative behaviours.
- Participants reported a change in perception about themselves and engagement in school.</td></tr>
<tr><td colspan="2">Limitations:
- Sample size too small to make any generalisations (n=10, with only 7 completing the study).</td></tr>
<tr><td>Adaptions made to original intervention/program:</td><td>Record:</td></tr>
<tr><td>N/A</td><td>N/A</td></tr>
<tr><td colspan="2">Related records:
N/A</td></tr>
</table>

Table 46: Self-Regulated Learning and Calibration (SRL and Calibration)

Name and type of intervention: Self-regulated learning and calibration (SRL and calibration)	
Description of the intervention A control and intervention group both attended five 45-minute sessions over three weeks; these were conducted by a teacher, delivered to groups of 3-5 students at a time, and scheduled during non-academic periods. In each session, both groups were given five maths questions involving material recently covered in usual maths classes. Prior to and after working on the maths tasks, they completed confidence judgements, ie Likert-scaled questions regarding how well they thought they would (respectively had) complete(d) the tasks. The control group spent the remainder of their sessions using a maths computer program. The intervention group additionally received - explicit instruction on Zimmerman's three-stage SRL model: o an overview; o the three regulatory strategies of planning, monitoring, and reflection, in sequence, and in the context of the maths strategies taught in usual classes; o a review including how the processes complement one another. - a graph of the accuracy of their calibration (judgement versus performance) over the course of the intervention; - a self-reflection-prompting worksheet.	
First record (full reference, must contain detailed methods, including details of implementation and evaluation): Digiacomo, G., & Chen, P. P. (2016). Enhancing self-regulatory skills through an intervention embedded in a middle school mathematics curriculum. *Psychology in the Schools*, *53*(6), 601-616. https://doi.org/https://doi.org/10.1002/pits.21929	
Outcomes measured: maths performance, pre- and post- performance confidence judgements, calibration accuracy (the (absolute) difference between performance and the respective confidence judgements), qualitative measures of SRL strategies.	
Strengths: The intervention group improved performance on maths tasks over the control and had more accurate judgement/prediction of their performance.	
Limitations: Domain specific; small sample size; short duration; no consideration of transfer or persistence; conducted in very small groups outside of usual lesson times; conducted in small private school (limited variation of sociodemographic characteristics).	
Adaptions made to original intervention/program:	**Record:**
N/A	
Related records: N/A	

Table 47: SRL Mentoring

Name and type of intervention:

SRL mentoring

Description of the intervention

The intervention was a school–based mentoring program designed to increase self-regulated learning and academic achievement of middle-school students and conducted over one school year. Students in the intervention group received weekly one-hour mentoring sessions, held after school, in groups of three or four, with mentors being randomly assigned teachers. The comparison group had an hour of class time (not attended by the intervention group) in which they practised study skills and learning strategies. All students were provided with information on learning skills and SRL processes.

The mentoring groups focused on the application of SRL strategies (e.g., goal-setting, self-monitoring, self-reflection, strategic planning, and organisation) in various learning situations, with students assisted to reflect on their study practices, discuss their strategy use with the group, and explore potential future applications of strategies across diverse learning settings.

Teacher/mentors participated in a 2-day training workshop prior to the intervention, a further two 1-day workshops during the school year and met with researchers biweekly throughout the school year.

First record (full reference, must contain detailed methods, including details of implementation and evaluation):

Núñez, J. C., Rosário, P., Vallejo, G., & González-Pienda, J. A. (2013). A longitudinal assessment of the effectiveness of a school-based mentoring program in middle school. *Contemporary Educational Psychology*, *38*(1), 11-21. https://doi.org/https://doi.org/10.1016/j.cedpsych.2012.10.002

Outcomes measured:

SRL strategies, self-efficacy for SRL; perceived usefulness of SRL; atudy time (via daily logs); academic achievement (language – native and mathematics). Measured at four time points spaced across the school year.

Strengths:

Longer term intervention (1 school year). Domain general. Multiple measures of outcomes over intervention period. Intervention increased effectiveness of SRL and mathematics achievement.

Limitations:

Mentoring conducted after school and resource intensive. No follow up measures after intervention ceased.

Adaptions made to original intervention/program:	**Record:**
N/A	

Related records:

N/A

Table 48: SRL and Maths Strategy Training

<table>
<tr><td colspan="2">Name and type of intervention:
SRL and maths strategy training</td></tr>
<tr><td colspan="2">Description of the intervention
Implementation was over seven weeks, with one 90-minute session conducted by “qualified trainers” each week during regular school classes. Students received a learning diary, to be filled out daily over the course of the intervention. Teachers were involved in the preparation of the training materials to assist in alignment with curricular content. Sessions alternated in focus between interdisciplinary self-regulatory strategies (goal-setting, planning, motivation, concentration, evaluation, reflection, modification of goals/strategies) and their application in the pre-action, action, and post-action phases of the learning process, and subject-specific mathematical problem-solving strategies.</td></tr>
<tr><td colspan="2">First record (full reference, must contain detailed methods, including details of implementation and evaluation):
Otto, B., & Kistner, S. (2017). Is there a Matthew effect in self-regulated learning and mathematical strategy application? - Assessing the effects of a training program with standardized learning diaries. Learning and Individual Differences, 55, 75-86. https://doi.org/https://doi.org/10.1016/j.lindif.2017.03.005</td></tr>
<tr><td colspan="2">Outcomes measured:
Realistic goal-setting, planning of learning strategies, self-efficacy, intrinsic motivation before and during learning, procrastination, application of motivational strategy of encouragement, positive and negative emotions before learning, application of problem-solving strategies, ability to concentrate, application of concentration strategies, actual time needed for learning, goal attainment, understanding of learning material, perceived simplicity of the learning task, reflection, satisfaction with the learning outcome (all via daily self-recording, i.e. learning diaries)</td></tr>
<tr><td colspan="2">Strengths:
Found positive effects of the intervention on intended/measured outcomes.</td></tr>
<tr><td colspan="2">Limitations:
No control. No objective measure of outcomes (all self-reported). Intervention more beneficial for pre-identified “high achievers” than “low achievers”.</td></tr>
<tr><td>Adaptions made to original intervention/program:</td><td>Record:</td></tr>
<tr><td>N/A</td><td></td></tr>
<tr><td colspan="2">Related records:
N/A</td></tr>
</table>

Table 49: SRL Training in the Mathematics Classroom

<table>
<tr><td colspan="2">Name and type of intervention:

SRL training in the mathematics classroom</td></tr>
<tr><td colspan="2">Description of the intervention
Intervention conducted during usual maths classes over a six-week period (replacing one 45-minute session each week). The content, focused on metacognitive strategies, including goal setting, strategic planning, organising, comprehension monitoring, attention focusing, and causal attribution, was divided into six units. A fictitious character (a nine-year old bear), developed by the researchers, was used to relay the information to the students and guide them through the units in a relatable and playful manner.
A week prior to the start of the intervention, teachers were provided with learning materials, instructions for teaching, and supporting documents explaining the theoretical background of the units. They were expected to familiarise themselves with the materials, with a mentor available on request. Each unit (session) began with a review of the previous unit, then teachers demonstrated a new problem facing the bear character, the students thought about the problem and potential strategies, and/or learned how the character had solved the problem by itself, and finally needed to transfer the strategies to their own learning behaviour. A homework task was given each session, with a structured learning diary to be filled out before and after completing each homework task.
A control group received usual classes, with no training or diaries.</td></tr>
<tr><td colspan="2">First record (full reference, must contain detailed methods, including details of implementation and evaluation):
Leidinger, M., & Perels, F. (2012). Training Self-Regulated Learning in the Classroom: Development and Evaluation of Learning Materials to Train Self-Regulated Learning during Regular Mathematics Lessons at Primary School. Education Research International, 2012, 735790. https://doi.org/10.1155/2012/735790</td></tr>
<tr><td colspan="2">Outcomes measured:
Self-regulated learning: via (i) questionnaire pre, immediately post, and twelve months after the intervention and (ii) the learning diaries.
Mathematics performance (standardised test); pre and post intervention (different versions)</td></tr>
<tr><td colspan="2">Strengths:
Intervention improved self-regulated learning and this was stable at a 12-month follow-up. General metacognitive strategy instruction applied in mathematics classroom; also improved maths performance more than control.</td></tr>
<tr><td colspan="2">Limitations:
Domain specific. Short duration. Control group showed unexpected decline in SRL. Materials developed specifically for particular age group so applicability narrow.</td></tr>
<tr><td>Adaptions made to original intervention/program:</td><td>Record:</td></tr>
<tr><td>Original intervention conducted after-school hours. Below record adapts to incorporate into usual maths classes.</td><td>Perels, F., Gürtler, T., & Schmitz, B. (2005). Training of self-regulatory and problem-solving competence. Learning and Instruction, 15(2), 123-139. https://doi.org/https://doi.org/10.1016/ j.learninstruc.2005.04.010</td></tr>
<tr><td>Current record expanded sample from 53 to 135 students; expanded duration from three to six weeks; implemented in multiple schools instead of one; applied to fourth graders</td><td>Perels, F., Dignath, C., & Schmitz, B. (2009). Is it possible to improve mathematical achievement by means of self-regulation strategies? Evaluation of an intervention in regular math</td></tr>
</table>

instead of sixth; added a learning diary component.	classes. *European Journal of Psychology of Education*, *24*(1), 17-31. https://doi.org/10.1007/BF03173472
Uses learning diaries as sole intervention treatment within the same theoretical framework; current record uses learning diaries of one of several components.	Schmitz, B., & Perels, F. (2011). Self-monitoring of self-regulation during math homework behaviour using standardized diaries. *Metacognition and Learning*, *6*(3), 255-273. https://doi.org/10.1007/s11409-011-9076-6
Related records: N/A	

Table 50: Student Success Skills (SSS)

Name and type of intervention: Student Success Skills (SSS)
Description of the intervention: - A school counselling intervention program delivered by school counsellors to students in Years 5, 6, 8 and 9. - Primary interventions provided by counsellors included group counselling and classroom guidance using the SSS curriculum. - School counsellors trained in three areas: topics (the SSS curriculum), format (the structured group and classroom guidance session format) and skills (counsellor group discussion and leadership skills). - Counsellors attend 3 days of training plus 3 half-day training sessions. - The SSS curriculum: focused on the three topics of cognitive, social and self-management skills. These three skill areas were selected as they were considered to be the most effective route to improved student academic achievement and social performance. Group Counselling Intervention - Group counselling intervention involved 8 weekly sessions of 45 minutes each followed by 4 booster sessions. Booster sessions were spaced a month apart. - Format for group sessions divided into three sections: beginning, middle and ending. - First phase of group sessions: The beginning phase involves four tasks (1) temperature check on feelings/energy. A life skills form was used to track patterns associated with fun, rest, exercise and diet; (2) review of the past session; (3) goals and progress associated with academic achievement and school success behaviour. - Second phase of group sessions: main activity introduced and explored. Leaders are asked to use the "Ask, Tell, Show, Do" method of skill/knowledge building. - Ending phase of group sessions includes four tasks: (1) review what was covered in the session; (2) process/discuss thoughts and feelings participants had during their participation in session's activities' (3) set a goal(s) and; (4) leader previews what is coming up in the next session. Format for Classroom Guidance Lessons - Includes three main topics: (1) cognitive skills which include memory strategies, goal setting, and progress monitoring; (2) social skills which include conflict resolution, social problem solving and teamwork skills and (3); self-management skills which include anger management, motivation and career awareness. - Counsellor facilitates classroom lessons. - Format of lessons is similar in format to group counselling intervention. - First activity involves introduction and lesson 'hook' along with a WIIFM (what's in it for me benefit statement from students' point of view). - Activity two involves presenting and discussing information to class. - Activity three involves time for students to explore the topic further. Counsellor moves around amongst the small groups or pairs. - Activity four involves small groups reporting to whole class and individual student summaries of content and personal goal setting.

First record (full reference, must contain detailed methods, including details of implementation and evaluation):
Brigman, G., & Campbell, C. (2003). Helping students improve academic achievement and school success behavior. *Professional School Counseling, 7,* 91–98.

Outcomes measured:

- Mathematics and reading.
- School connection.

Strengths:

- Supports students' academic achievement by means of ameliorating foundational learning skills, attitudes and classroom climates necessary for success in school.
- Found improved behaviour in seven out of every ten treatment students.
- 82% of treatment students showed improvement in mathematics and 61% showed improvement in reading.
- Fosters school and social connection.
- Delivered by school counsellors.

Limitations:

- May be difficult for some schools to deliver if they only have a small student counselling team.
- Requires students to feel comfortable enough to share personal goals and learning in group settings.

Adaptions made to original intervention/program:	**Record:**
- SSS trialled only with Year 4 and 5 students. - Used only the eight-session small-group counselling component.	Lemberger, M. E., & Clemens, E. V. (2012). Connectedness and self-regulation as constructs of the student success skills program in inner-city African American elementary school students [Article]. *Journal of Counseling and Development*, *90*(4), 450-458. https://doi.org/10.1002/j.1556-6676.2012.00056.x

Related records:
Lemberger, M. E., & Clemens, E. V. (2012). Connectedness and self-regulation as constructs of the student success skills program in inner-city African American elementary school students [Article]. *Journal of Counseling and Development*, *90*(4), 450-458. https://doi.org/10.1002/j.1556-6676.2012.00056.x

Table 51: Thinking Science Cognitive Acceleration Intervention

Name and type of intervention: Thinking Science Cognitive Acceleration Intervention	
Description of the intervention: - The theoretical origins of *Thinking Science* are based on the writings of Piaget and Vygotsky. - The classroom intervention involves 30 thinking lessons that are implemented by science teachers over a period of 2 years when students are in Years 7–9. Students are required to participate in a thinking lesson instead of a regular science lesson about every 2 weeks. - The lessons draw on Piagetian schemata of formal operations, for example, variables, proportionality, probability, correlation, formal models, and equilibrium. Each lesson incorporates five important pedagogical strategies including concrete preparation, cognitive conflict, social construction, metacognition, and bridging. - This program involved the adaptation of the *Thinking Science* materials to the Australian school context and professional development for science teachers in eight schools including one academically selective school that is the focus of the research reported in this paper. Over the course of 2 years, the science teachers from the eight schools participated in 6 days of professional development away from school. In the initial, 2-day workshop, teachers were introduced to the teaching materials, activities and the theoretical underpinnings of the program. Program leaders modelled lessons during the workshop, and these were then 'unpacked' to identify the different principles.	
First record (full reference, must contain detailed methods, including details of implementation and evaluation): Venville, G., & Oliver, M. (2015). The impact of a cognitive acceleration programme in science on students in an academically selective high school. *Thinking Skills and Creativity*, *15*, 48-60. https://doi.org/https://doi.org/10.1016/j.tsc.2014.11.004	
Outcomes measured: - Student cognition levels	
Strengths: - Intervention designed to meet Australian Curriculum standards. - Intervention trialled in an Australian school context.	
Limitations: - Intervention spans 2 years. - Study was conducted in one academically selective school.	
Adaptions made to original intervention/program:	**Record:**
N/A	N/A
Related records: Adey, P., Shayer, M., & Yates, C. (1989). *Thinking Science: Student and teachers' materials for the CASE intervention*. London: Macmillan. *(NOTE: This is the original record of the Thinking Science program developed in the UK. Unable to locate a copy of this record.)*	

Table 52: Thinking Your Problems Away

Name and type of intervention:

Thinking Your Problems Away

Description of the intervention

The intervention was delivered to small groups in schools by teaching assistants (TAs). The TAs received training from researchers prior to the intervention and were provided with scripts and resources for all sessions. The intervention comprised twelve 45-minute sessions over 4 weeks. A matched control group attended usual maths classes, and were told that they would receive the intervention the following term.

The intervention sessions focused on 5 key activities:

- mindful breathing;
- using metacognitive questioning method (IMPROVE – see related record below) to work through maths problems;
- modelling and peer talk;
- jokes and comic strips;
- self-coping statements.

First record (full reference, must contain detailed methods, including details of implementation and evaluation):

Collingwood, N., & Dewey, J. (2018). 'Thinking Your Problems Away': Can maths interventions be developed to address both the academic and affective aspects of learning in primary aged children? *Educational & Child Psychology*, 76-92. https://doi.org/10.53841/bpsecp.2018.35.2.76

Outcomes measured:

Maths performance, self-regulation, mathematical self-concept and maths anxiety (pre- and post-intervention).

Strengths:

The intervention improved maths performance.

Limitations:

Domain specific. No significant effect found on self-regulation, self-concept, or maths anxiety levels. Persistence was not investigated. Intervention and control groups were both told aim of intervention.

Adaptions made to original intervention/program:	**Record:**
Selected particular problems to align with the local maths curriculum; added further components to intervention as detailed above.	Mevarech, Z. & Kramarski, B. (1997). Improve: A multidimensional method for teaching mathematics in heterogeneous classrooms. *American Educational Research Journal*, *34*(2), 365–394.

Related records:

N/A

Table 53: Thought in Mind (TiM Project) Teacher Training

Name and type of intervention: Thought in Mind (TiM project) teacher training
Description of the intervention The intervention was implemented over one school year by teachers (two teachers/classes – one each for TiM and control). Both teachers received two 3-hour training sessions prior to the intervention plus two further supervision sessions during the school year. Teachers were free to implement the training in their classrooms in any way they wished and could request support/advice from the researchers whenever desired throughout the intervention. The control group teacher's training focused on teaching strategies and the principles of cooperative and collaborative learning. The TiM teacher's training focused on metacognitive approaches to resilience and self-control, with conceptual explanations accompanied by suggestions for stories, activities and games to use with children. Key concepts included - the importance of awareness of one's own thoughts and self-reflection; - resilience and the body-mind relationship; - cognitive and emotional regulation strategies. The TiM intervention teacher was also provided with a TiM Project Manual.
First record (full reference, must contain detailed methods, including details of implementation and evaluation): Valle, A., Massaro, D., Castelli, I., Intra, F. S., Lombardi, E., Bracaglia, E., & Marchetti, A. (2016). Promoting mentalizing in pupils by acting on teachers: Preliminary Italian evidence of the "Thought in Mind" project [Article]. *Frontiers in Psychology*, *7*(AUG), Article 01213. https://doi.org/10.3389/fpsyg.2016.01213
Outcomes measured: - Mentalizing attributional styles (Mentalizing Task) - Theory of mind competence (False Belief Tasks) and application (Strange Stories) - Affective component of theory of mind (Reading the Mind in the Eyes Test – Child version) All conducted pre- and post- intervention.
Strengths: Domain general. Teacher training reasonably short and exact implementation adapted/decided by teachers (incorporated into usual classrooms).
Limitations: Small sample size. Results dependent on one teacher's individual implementation (may not replicate).

Adaptions made to original intervention/program:	**Record:**
Different age group (first implementation with ten-year olds). Intervention trains teachers only (doesn't include parent-training).	Bak, P. L. (2012). 'Thoughts in Mind': Promoting mentalizing communities for children. In N. Midgley & I. Vrouva (Eds.), *Minding the child: Mentalization-based interventions with children, young people and their families* (pp. 202–217). Routledge/Taylor & Francis Group

Related records: N/A

Table 54: Thought in Mind Child Training Program (TiM-C)

Name and type of intervention: Thought in Mind Child training program (TiM-C)	
Description of the intervention: - Involves three sessions. - Session 1 (pre-test): all children tested through a collective session and two individual sessions. Collective session which lasts for 50 minutes, assesses socioeconomic level, verbal ability and reading comprehension. Two individual sessions last for 25 minutes and evaluate children's inhibitory control, metacognition, emotion regulation strategies and ToM tasks. - Session 2 (training): Contains two training conditions one week after pre-test. (1) TiM-C guides children to learn about functioning of the mind and to propose strategies to train children to manage their thoughts in stressful moments. (2) Control training involving stories and language exercises about physical states. Training lasted for 4 consecutive weeks using 2 weekly classroom sessions (2 stories per session) of approximately 1 hour each. Training sessions conducted in the classroom. Training is based on narratives followed by questions about the story and a language exercise that involves mental state verbs. Focus of the training program is the use of group conversations about mental states which provide an opportunity to elaborate on children's comments, explaining why their answers are right or wrong and emphasising existence of different points of view. - Session 3 (post-test): all children took part in this session 1 week after training sessions had finished.	
First record (full reference, must contain detailed methods, including details of implementation and evaluation): Lombardi, E., Valle, A., Bianco, F., Castelli, I., Massaro, D., & Marchetti, A. (2022). Supporting mentalizing in primary school children: the effects of thoughts in mind project for children (TiM-C) on metacognition, emotion regulation and theory of mind [Article]. *Cognition and Emotion*, *36*(5), 975-986. https://doi.org/10.1080/02699931.2022.2067521	
Outcomes measured: - Emotion regulation skills - Metacognition - Mentalizing	
Strengths: - Can be conducted in an everyday classroom environment. - Achievable time frame for delivery of program. - Use of narrative genre is suitable for age range (8- to 9-year-olds).	
Limitations: - Reliance on children's verbal comprehension skills.	
Adaptions made to original intervention/program:	**Record:**
N/A	N/A
Related records: N/A	

Table 55: Training Activities

Name and type of intervention: Training Activities	
Description of the intervention: - Consists of 8 sessions, one-hour sessions delivered once a week. Sessions held collectively, but children worked on their own. At the beginning of each session, students were provided with materials specifically designed for activities with the researcher introducing them before students worked independently. - First five minutes of sessions dedicated to summarising main topics covered in previous session. - After briefly summarizing the activities involved in the previous session (5 minutes), the trainer introduced the metacognitive activities (20 minutes). Then, 10 minutes were spent on working memory (WM) exercises involving variations of classical WM tests, such as the listening span test (LST). The last 20 minutes were devoted to talking about components of problem solving, also referring to the previous activities on WM and metacognition and associating them more specifically with problem solving. - Examples of content of activities and examples of specific activities contained in Tables 2 and 3. - Each session consisted of three intervention areas: metacognitive beliefs, working memory and problem-solving components.	
First record (full reference, must contain detailed methods, including details of implementation and evaluation): Cornoldi, C., Carretti, B., Drusi, S., & Tencati, C. (2015). Improving problem solving in primary school students: The effect of a training programme focusing on metacognition and working memory. *British Journal Educational Psychology*, *85*(3), 424-439. https://doi.org/10.1111/bjep.12083	
Outcomes measured: - Association between initial performance in metacognition, WM updating and problem solving.	
Strengths: - Training activities can be conducted with a whole class by suitably trained class teachers.	
Limitations: - No control group used in study to examine the separate effects of the WM training and of the metacognitive activities on the improvement in problem-solving skills.	
Adaptions made to original intervention/program:	**Record:**
N/A	N/A
Related records: N/A	

Table 56: Training Program

Name and type of intervention: Training Program
Description of the intervention: - Three types if training sessions (two experimental and one control) each consisting of four sessions lasting approximately 50 minutes each and administered twice a week. Children post-tested two weeks after training has been completed. - Structure of experimental and control sessions were similar. Four sessions involved group conversations about two narratives and two language exercises receiving a total of eight narratives (two for each of the four training sessions) and eight learning exercises (two for each of the four training sessions). - Each training trial followed a predictable sequence in which: in which: (1) the experimenter read aloud the story to children; (2) children first worked individually, answering the multiple-choice questions about the given narrative; (3) children were involved by the experimenter in a group conversation on their answers and on their point of views about the target social scenario; (4) children were proposed to imagine an episode similar to the one presented in the story; (5) children filled in the language exercise, where they were presented with a sentence extrapolated from the text of the story and were requested to find the synonymous of a target word/verb. After all children had written down their own answers to this last task, the experimenter opened a group conversation on the meaning of the chosen verb based on the individual responses. During these conversations, the experimenter used the story/language questions as prompts, paying specific attention to children's participation: the experimenter ensured that all children took part in the conversation, discussed their points of view on the story and gave corrective feedback when needed. For each training session, the group discussion was concluded when all participants showed a good understanding of the central aspect involved in the focus narrative. - Researchers used scripts to develop group conversations. - Used false belief tasks.
First record (full reference, must contain detailed methods, including details of implementation and evaluation): Bianco, F., Lombardi, E., Lecce, S., Marchetti, A., Massaro, D., Valle, A., & Castelli, I. (2021). Supporting Children's Second-order Recursive Thinking and Advanced ToM Abilities: a Training Study [Journal article]. *Journal of Cognition and Development*, *22*(4), 561-584. https://doi.org/10.1080/15248372.2021.1901712
Outcomes measured: - Understanding of narratives.
Strengths: - Scaffolding provided to prompt group conversation. - Suitable for junior primary students. - Ability to deliver within classroom over a relatively short time period.

Limitations: - Relies heavily upon children's reading comprehension and linguistic abilities.	
Adaptions made to original intervention/program:	**Record:**
N/A	N/A
Related records: N/A	

Table 57: Problem Solving Transfer Instruction Plus Self-Regulated Learning (Transfer plus SRL)

Name and type of intervention: Problem solving transfer instruction plus self-regulated learning (Transfer plus SRL)	
Description of the intervention The intervention was delivered to third grade students primarily by their usual teachers. One group received a problem-solving transfer intervention, a second group the problem-solving transfer plus self-regulated learning, and a third group was a control, receiving usual maths lessons. All groups followed the usual maths curriculum. The intervention consisted of 32 sessions over 16 weeks: five units, each comprising six sessions, plus 2 review sessions. The transfer component included explicit teaching of: problem solving methods, types and features of problems, the meaning and application of transfer, and metacognitive prompting to use transfer. For intervention groups, the first session of each unit was delivered by a researcher with teacher present (and the remainder by the teachers). Sessions included worked examples with explanations, practice in pairs, independent problem completion and solution-checking, assignment of homework, and submission of homework from previous session. The SRL component added: student goal-setting, self-evaluation of both process and accuracy of independent problem-solving, and graphing of their daily scores on individual graphs. SRL students scored their own homework assignments and graphed homework completion on a class graph; they also identified opportunities to apply skills outside of instructional sessions, discussed those opportunities with partners, and reported them to the class.	
First record (full reference, must contain detailed methods, including details of implementation and evaluation): Fuchs, L. S., Fuchs, D., Prentice, K., Burch, M., Hamlett, C. L., Owen, R., & Schroeter, K. (2003). Enhancing third-grade students' mathematical problem solving with self-regulated learning strategies. *Journal of Educational Psychology*, *95*(2), 306. https://doi.org/10.1037/0022-0663.95.2.306	
Outcomes measured: Problem solving: immediate, near and far transfer tasks; Self-regulation processes: self-efficacy, goal orientation, self-monitoring, and effort, via questionnaire	
Strengths: General strategies within specific domain of mathematics (ie, promotes identifying similarities between problems and applying techniques in various ways). Delivered in classroom with usual curriculum. SRL increased effectiveness of the transfer intervention on immediate and near transfer, and was effective (transfer alone was not) at far transfer task.	
Limitations: Didn't investigate persistence. Domain specific.	
Adaptions made to original intervention/program:	**Record:**
Original study had a transfer intervention group and a control group; current study adds a transfer plus SRL group. The problem transfer component has been modified to: add an introductory unit, expand coverage of one problem type from one to two units, add a task of independently completing and self-checking	Fuchs, L. S., Fuchs, D., Prentice, K., Burch, M., Hamlett, C. L., Owen, R., Hosp, M., & Jancek, D. (2003). Explicitly teaching for transfer: Effects on third-grade students' mathematical problem solving. *Journal of Educational Psychology, 95*(2), 293–305. https://doi.org/10.1037/0022-0663.95.2.293

a problem to the end of each session, and add a homework component.	

Related records:
N/A

Table 58: Triangulating Chemistry (ETC)

Name and type of intervention: Triangulating Chemistry (ETC)	
Description of the intervention Intervention took place in one chemistry classroom of a school over twenty weeks. The initial eight weeks were baseline data collection (researcher observations of teaching, interviews with students, etc). The mode of presentation of the intervention/modification of usual pedagogy was then developed collaboratively by the teacher and researcher over a two-week period, followed by a ten-week implementation of the intervention in usual chemistry classes. The metacognitive framework used was "triangulation", with each of the three nodes of the triangle an aspect (representation) of chemical concepts/phenomena: Empirical (macroscopic/observable), Theoretical (molecular/atomic), and Communicative (symbolic). After explicitly introducing the idea of triangulation as a way of thinking about, understanding, and relating the different representations of concepts, the teacher used it as a framework for all material presented in class, with an explicit intention of stimulating students' metacognitive reflection. The researcher provided a worksheet/template for triangulation that included metacognitive questions/prompts.	
First record (full reference, must contain detailed methods, including details of implementation and evaluation): Thomas, G. P. (2017). 'Triangulation:' an expression for stimulating metacognitive reflection regarding the use of 'triplet' representations for chemistry learning [Article]. *Chemistry Education Research and Practice*, *18*(4), 533-548. https://doi.org/10.1039/c6rp00227g	
Outcomes measured: Metacognition (in the context of science learning), via two tests, both pre- and post-intervention - MOLES-S (Metacognitive Orientation Learning Environment Scale (Science) - SEMLI-S (Self-Efficacy, Metacognition, and Learning Inventory – Science)	
Strengths: Integrated into usual classroom teaching; framework/heuristic could be used for all concepts in course.	
Limitations: Very small sample; no control. Domain specific to chemistry and limited outcomes measured.	
Adaptions made to original intervention/program:	**Record:**
N/A	
Related records: N/A	

Table 59: Write to Learn in Science

<table>
<tr><td colspan="2">Name and type of intervention:
Write to Learn in Science</td></tr>
<tr><td colspan="2">Description of the intervention:
- Engaged students in two types of writing at select intervals throughout intervention: metacognitive writing and argumentative writing.
- Metacognitive writing took place twice a week at the end of the class period. Template was provided and students asked to describe what they had learned that day to a friend who was absent from class. The goal of this task was to prompt metacognitive writing (i.e., writing about one's own learning and thought process) while providing an authentic audience (a peer who needed to know what he or she had missed). These metacognitive assignments formed the basis of the intervention, providing students with opportunities to practice writing about scientific content.
- The longer argumentative writing occurred three times throughout the intervention – once after the first week, once at the midpoint, and once at the end of the intervention. This assignment varied slightly for each class depending on the content taught at that time; however, the general format remained the same to allow for pre- and postintervention and grade-level comparisons. Students were provided with an inaccurate scientific statement published in a mock journal and were asked to write a letter to the editor describing what was incorrect and providing the correct information. Argumentative assignments provided students with further opportunities to practice writing, engage in higher order thinking, and acquire content knowledge.</td></tr>
<tr><td colspan="2">First record (full reference, must contain detailed methods, including details of implementation and evaluation):
Wright, K. L., Hodges, T. S., Zimmer, W. K., & McTigue, E. M. (2019). Writing-to-Learn in Secondary Science Classes: For Whom Is It Effective? Reading and Writing Quarterly, 35(4), 289-304. https://doi.org/10.1080/10573569.2018.1541769</td></tr>
<tr><td colspan="2">Outcomes measured:
- Scientific writing
- Scientific knowledge
- Metacognitive knowledge and control</td></tr>
<tr><td colspan="2">Strengths:
- Suitable for a large age range of students.
- Can be used with whole class.</td></tr>
<tr><td colspan="2">Limitations:
- No control group used to isolate effects of intervention.
- Small sample size from one geographical location.
- Relies heavily on students' literacy skills.</td></tr>
<tr><td>Adaptions made to original intervention/program:</td><td>Record:</td></tr>
<tr><td>N/A</td><td>N/A</td></tr>
<tr><td colspan="2">Related records: N/A</td></tr>
</table>

Table 60: Writing Routines

Name and type of intervention: Writing routines	
Description of the intervention Two separate interventions were conducted, both focusing on writing synthesis texts via writing routines focusing either on preplanning or drafting (revising). The second intervention included an explicit metacognitive component. This consisted of one session during which students received their outcome from an initial writing approach task and related their scores to averages from a national baseline study. They were provided with information regarding synthesis writing strategies, then directed to compare their own approaches with these, evaluate, reflect, and adjust their writing plan accordingly.	
First record (full reference, must contain detailed methods, including details of implementation and evaluation): van Ockenburg, L., van Weijen, D., & Rijlaarsdam, G. (2023). Choosing how to plan informative synthesis texts: Effects of strategy-based interventions on overall text quality [Article]. *Reading and Writing*, *36*(4), 997-1023. https://doi.org/10.1007/s11145-021-10226-6	
Outcomes measured: Writing routines (two aspects: preplanning and drafting (revising)), measured via Writing Style Inventory (WSI) Text quality	
Strengths: Including the metacognitive component in the intervention increased awareness of writing strategy use.	
Limitations: Domain specific. Explicit metacognitive component of intervention very brief. Limited quantitative analyses.	
Adaptions made to original intervention/program:	**Record:**
N/A	
Related records: N/A	

Table 61: Writing Wings with Multimedia (WWM)

Name and type of intervention: Writing Wings with Multimedia (WWM)
Description of the intervention: - Program uses a writing process approach with a strong emphasis on cooperative learning as well as embedded multimedia segments in which humorous skits model components of the writing process, cooperative learning, writing genres and metacognitive strategies. - Teachers received one day of training at the beginning of the year and were then visited by coaches four times over the course of the year. The main elements of Writing Wings with Media were as follows: Teams - Students were assigned to 4-member learning teams, including high, average, and low achievers, boys and girls, and students from any ethnic groups represented in the class. If the class did not divide evenly by four, some teams had 5 members. Writing process elements - Plan: Students worked with teammates to plan what they were going to write. - Draft: Students wrote a draft, or "sloppy copy," of their composition. - Revise: After a partner critiqued the draft (based solely on content, organization, and style, not mechanics), the writer wrote a revision. - Edit: A partner read the revised draft and suggested edits based on grammar, punctuation, usage, and spelling. Initially, partners focused on a small set of issues (e.g., capital letters at the beginning of each sentence), but as lessons on mechanics skills were presented, these skills were added to an editing checklist. - Publish: After a final review by the teacher and final revisions, students had opportunities to present their final compositions to the class, to create a team book or newspaper, or otherwise celebrate their writing products in a public forum. Multimedia - Students viewed a series of video vignettes illustrating the elements of writing process in various genres. A team of puppets, the Write-On Dudes, modelled the process. The video team included a student who tended to think she had little to say, one who had trouble with organization, one who tended to overwrite, and one who tended to lack detail. In the puppets' interactions, effective cooperative behaviours as well as writing behaviours were modelled, and metacognitive strategies adapted from CSIW and SRSD were demonstrated. In addition, students viewed a series of live-action skits and animations that presented humorous demonstrations of key elements of grammar, punctuation, and usage.
First record (full reference, must contain detailed methods, including details of implementation and evaluation): Madden, N. A., Slavin, R. E., Logan, M., & Cheung, A. (2011). Effects of cooperative writing with embedded multimedia: A randomized experiment. *Effective Education*, *3*(1), 1-9. https://doi.org/10.1080/19415532.2011.603914

<table>
<tr><td colspan="2">Outcomes measured:
- Writing</td></tr>
<tr><td colspan="2">Strengths:
- Can be delivered by classroom teacher with minimal training required.
- Use of a sequential writing process.</td></tr>
<tr><td colspan="2">Limitations:
- Significant focus on writing outcomes rather than metacognitive improvements.
- Time required for intervention (one year).</td></tr>
<tr><td>Adaptions made to original intervention/program:</td><td>Record:</td></tr>
<tr><td>N/A</td><td>N/A</td></tr>
<tr><td colspan="2">Related records:
N/A</td></tr>
</table>