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Metacognition and Self-Regulation: Evidence Review

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The EEF Guidance Report ***Metacognition and Self-Regulated Learning*** is available at: https://educationendowmentfoundation.org.uk/tools/guidance-reports/metacognition-and-self-regulated-learning/

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1. Introduction to definitions and models

Metacognition and self-regulated learning (SLR) have been advocated by many, and have significant support being seen as a potentially effective and low cost way of impacting learning (see https://educationendowmentfoundation.org.uk/resources/teaching-learning-toolkit/meta-cognition-and-self-regulation/).

Fundamentally, the underlying supposition is that metacognition and SRL are important to learning, and thus raise attainment, and various studies have established that SRL, and in particular metacognition, has a significant impact on students' academic performance, on top of ability or prior achievement (e.g. Hacker, Dunlosky, & Graesser, 2009; Ponitz et al, 2008; Pressley & Harris, 2006). Veenman et al (2004) and Veenman & Spaans (cited in Veenman et al., 2006, p. 6) found that metacognitive skills and intelligence are moderately correlated. On average, intelligence uniquely accounts for 10% of variance in learning, metacognitive skills uniquely account for 17% of the variance, whereas both predictors together share another 20% of variance in learning for students of different ages and background, for different types of tasks, and for different domains. The implication, according to Veenman et al (2006), is that an adequate level of metacognition may compensate for students' cognitive limitations. Studies suggest that early forms of metacognition are predictive of later attainment, one study of Finnish children, for example, finding that metacognition at age 3 was directly predictive of mathematics performance at age 6, and indirectly predictive of rate of growth maths performance between ages 3 and 6 (largely through its effect on counting ability) (Aunola et al, 2004).

However, there is some confusion around what the terms mean, with different authors defining them in different ways, and a lot of related terms, such as 'learning to learn' and 'higher order thinking skills' used as substitutes in often confusing ways. In fact, the scientific literature itself shows quite a bit of divergence in the ways the terms self-regulated learning and metacognition are used. This, for example, is illustrated by an overview of articles published in the field conducted in 2008 which found that the terms were used in a number of different ways (Dinsmore et al, 2008). Some critics have claimed that the terminological confusion is so great it makes the very use of the terms problematic (Martin & McLellan, 2009). This would, however, seem to overstate the extent of disagreement, as there are many commonalities in the definitions used. In Dinsmore et al's (2008) abovementioned overview some clarity emerged in terms of the words most frequently associated with the concepts of metacognition and self-regulated learning, as well as some clear differences between metacognition and self-regulated learning (see table 1).

Table 1. Frequency and Percent of Keywords in the Explicit Definitions by Construct, from Dinsmore at al (2008)

	Metacognition		**Self-regulation**	
	N	**Percent**	***N***	**Percent**
Monitor	20	51	11	35
Control	19	49	12	39
Regulate	17	44	–	
Cognition	–	15	48	

Motivation	01	03	13	42
Behavior	02	05	13	42
Knowledge	23	59	02	06

This study showed that metacognition is fundamentally associated with concepts such as monitoring, control, and knowledge. All of these (except for knowledge) reoccur in definitions of self-regulated learning, but in addition cognition and motivation appear strongly, suggesting that a key distinction between the two is the extent to which they include these components.

What is self-regulated learning?

Essentially, self-regulation is about the extent to which learners are aware of their strengths and weaknesses, the strategies they use to learn, can motivate themselves to engage in learning, and can develop strategies and tactics to enhance learning.

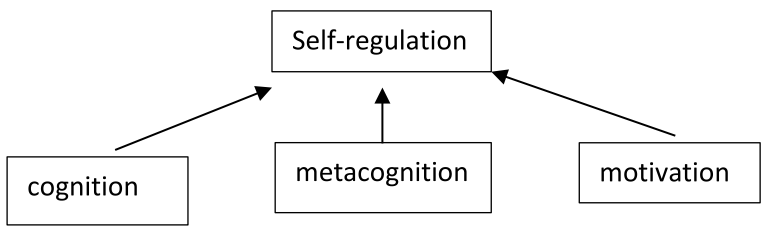
Metacognition, in turn, is specifically about the ways learners can monitor and purposefully direct their learning, for example by deciding that a particular strategy for memorisation is likely to be successful, monitor whether it has indeed been successful, and then deliberately change (or not change) their memorisation method based on that evidence.

Some studies consider self-regulation to be a part of metacognition, while others see metacognition as a part of self-regulation (Veenman et al, 2006). In recent years, however, the latter view has largely prevailed, so for clarity it is this definition that we will follow in this report.

The concept of self-regulated learning is based on the premise that students should take responsibility for their own learning and should play an active role in the learning process (Zimmerman, 2001). It is a cyclical process wherein learners regulate their learning in three phases: the forethought phase (i.e. processes that precede the learning act), the performance phase (i.e. processes during the learning act) and the self-reflection phase (i.e. processes after the learning act). These phases are cyclical as self-regulated learners use feedback from previous learning acts and attempt to make adjustments to future acts (Zimmerman, 2000).

As is evident from Dinsmore et al's (2008) review, self-regulation has been conceptualized as comprising three areas of psychological functioning: cognition, metacognition, and motivation. Cognition refers to the cognitive information-processing strategies that are applied to task performance, for example attention, rehearsal and elaboration. Metacognition refers to strategies to control and regulate cognition. Motivation and affect include all motivational beliefs about oneself related to a task, for example self-efficacy beliefs, interest, or emotional reactions to oneself and the task (Boekaerts, 1999).

Figure 1. Components of self-regulated learning



Each of these components of SRL is necessary, but not sufficient for learning, with all interacting in the learning process (Butler & Winne, 1995). For example, to return to a memorization task example, metacognition would consist of the decision on what method to use, e.g. using a mnemonic or interleaving, monitoring the successfulness of the strategy chosen, and adapting the strategy according to how successful it has been. Cognition consists of the actual use of the strategy, for example how I have engaged in interleaving (how many times have I repeated the learning, how much time have I left in between sessions), and motivation is the willingness to actually expend the effort in the first place (do I believe I can do it, is it worth me doing it).

According to Schraw, Crippen, and Hartley (2006), the role of metacognition is the most important, "because it enables individuals to monitor their current knowledge and skills levels, plan and allocate limited learning resources with optimal efficiency, and evaluate their current learning state" (p. 116). This has received some empirical confirmation in Dent and Koenka's (2015) meta-analysis of 61 studies: measures of metacognitive processes were more highly correlated with achievement than measures of use of cognitive strategies. They suggest this implies that 'deciding when to use different cognitive strategies may be more important than how frequently students enact them' (p. 459).

What is metacognition?

Like self-regulation, metacognition is generally conceptualized as consisting of different components. A common distinction made between the components is that between *metacognitive knowledge* and *metacognitive skills* (Veenman et al, 2006). Metacognitive *knowledge* is what a learner knows about the way they learn or how they can engage most efficiently with a particular task, while *skills* refer to the ability regulate these activities. Both are of key importance and interact with one another. Effective use of metacognitive skills entails the application of metacognitive knowledge which includes pupils' ability to assess or evaluate their progress on cognitive tasks *as well as* their ability to use strategies to regulate progress in a systematic manner (Karably & Zabrucky, 2009).

Schraw et al. (2006) call the two main components the *knowledge* of cognition and the *regulatio*n of cognition. Knowledge of cognition includes three subcomponents:

(1) Declarative knowledge: knowledge about oneself as a learner and about the factors that influences one's performance

(2) Procedural knowledge: knowledge about strategies and procedures such as reviewing, interleaving, organization strategies, elaboration strategies such as the creation of analogies, and selecting main ideas (Dent & Koenka, 2015)

(3) Conditional knowledge: knowledge of why and when to use a particular strategy.

Regulation of cognition includes at least three main components: *planning, monitoring* and *evaluation:*

(1) Planning relates to goal setting, activating relevant prior knowledge, selecting appropriate strategies, and the allocation of resources.
(2) Monitoring includes the self-testing activities that are necessary to control learning.

(3) Evaluation refers to appraising the outcomes and the (regulatory) processes of one's learning.

Essentially, then, metacognition can be seen as the instructions we give ourselves on how to do a particular learning activity or task, while cognition is the way we actually do them. Metacognition then returns as the monitoring of the success of these activities.

Some theorists have proposed that learners bring metacognitive knowledge and metacognitive skills together in metacognitive theories. These integrate knowledge about cognition and regulation of cognition. Shraw and Moshman (1995) suggest that there are three types of metacognitive theories. *Tacit* theories are those acquired or constructed without any explicit awareness that one possesses a theory. *Informal* theories are to some degree explicit but still fragmentary, with emerging recognition and control of learning processes. *Formal* theories are highly systematized accounts involving explicit theoretical structures. According to Shraw and Moshman (1995), greater expertise is associated with greater formalisation of theory.

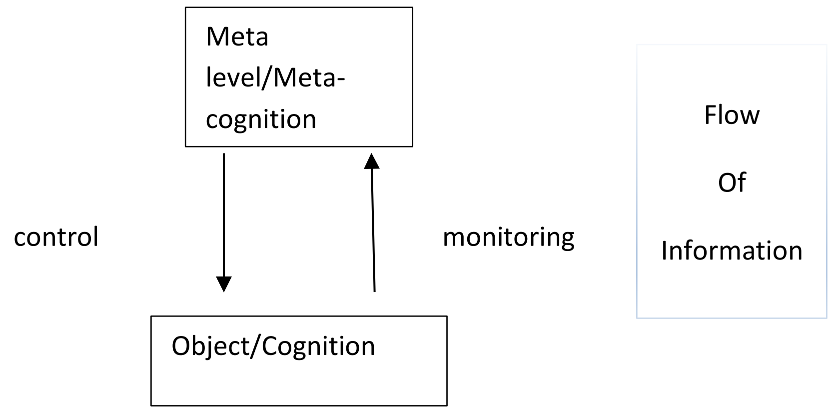
A key question in the field is the relationship between metacognition and cognition. While metacognition is the knowledge of cognition and strategies to regulate it, it would be mistaken to see metacognition as somehow 'higher order' hierarchically than cognition. Indeed, as Pressley (2006) has pointed out, it is very hard to have knowledge about how competent one is in a domain or how best one can learn in that domain without solid domain-specific knowledge. We need to know, for example, what key concepts are in a subject area, and how they relate to one another, not least in terms of difficulty. Likewise, it isn't possible to know what (metacognitive) skills to use to solve a problem without having a (cognitive) method to do so, for example by knowing a particular sequence in which to tackle the problem. The idea that metacognition is a higher order skill is also bought into question by the finding that some elements classified as metacognition, such differentiating between what one knows and what one doesn't know, are present in animals as well as humans. Like humans, animals opt out of difficult trials; avoid tests they are unlikely to answer correctly and take greater risks when their memories are accurate than they do when their memories are inaccurate (Kornell, 2009).

An important point is to remember that metacognitive knowledge can be wrong (we can underestimate the time we need to memorize something, for example), and metacognitive skills we use can be suboptimal in terms of effectiveness and efficiency. As such SRL can be either adaptive or maladaptive (Boekaerts & Cascallar, 2006). This is where schooling comes in, as we can improve both knowledge and skills through teaching and practise (Veenman et al, 2006). Recently, neuroscientists have attempted to look at the neural basis of metacognition, with findings suggesting that metacognitive activity is linked to activity in the anterior pre-frontal cortex. Experimental studies suggest that activity in this area of the brain is dependent on both sensory input and pre-existing knowledge, strategies and rules, and is closely connected to the other parts of the brain (Clark & Dumas, 2016).

Metamemory and metacognition

An important concept that is closely related to metacognition is *metamemory*. Metamemory has two main components. The first is *stable knowledge* of the variables that affect one's memory, such as an understanding that the size and/or quality of a person's memory is affected by individual ability, the relative difficulty of a task, and the relative effectiveness of different strategies. The second component of metamemory involves *monitoring*. Memory monitoring involves an individual's ability to judge how well he/she is performing on a memory task *and* the ability to use strategies to improve performance (Karably & Zabrucky, 2009; Flavell, Miller, & Miller, 2002). A key contribution to theory and research on metacognition and memory was made by Nelson & Narends (1996) who distinguish between an object-level (which can be equated to cognition) and a meta-level, which governs the object level. The meta-level controls and monitors the object level, and has a dynamic model of how the object level works. We can easily translate these levels into the cognition and metacognition levels as follows:

Figure 2. Meta level and object level (adapted from Nelson & Narends, 1996)



The meta-level controls the object level, and in turn is informed by it, so metacognition will provide a strategy for cognition, and will modify this based on feedback on the effectiveness of this strategy in practice.

Nelson and Narends (1996) relate these processes closely to the working of memory, and the acquisition and memorization of knowledge, in which they see the meta and object level constantly interacting. They illustrate this through the example of a learner memorizing or acquiring a piece of knowledge (for example for a test). The meta-level is involved in the control and monitoring of the process throughout. Thus, before learning, the learner will make a judgement of the '*Ease of Learning*' (EOL) of a particular piece of content. This will then lead her/him to select a particular strategy for processing the information. The learner will also make a '*Judgement of Knowing'*, by deciding how well s/he knows the content already, and allocating study time accordingly. A *Feeling-of-Knowing* judgement will then lead to a decision as to when to stop study. Once they have to retrieve the information on a test, their feeling of knowing judgement will lead them to select a search strategy to retrieve the information from long-term memory, or terminate the search. This is in part dependent on their confidence in the retrieved answer. All these elements are of course prone to error, so a task for schooling is to increase the accuracy of EOL, JOL and FOL, and get students to align these with appropriate strategies and study times.

The role of motivation in self-regulated learning

It is important not to forget the motivational component of self-regulation, and its relationship with cognition and metacognition. Monitoring and regulating cognition is an effortful process, and to make that effort requires motivation (Efklides, 2011). Motivation is, however, a very broad field, with a wide range of factors, variables and theories existing.

One factor that has been found to be related to more effective use of cognitive and metacognitive strategies, for example, is *delay of gratification*, with students who are better able to delay gratification in favour of studying, also are better at planning and regulating learning activities, and vice versa (Bembetty & Krabanick, 2004). *Self-efficacy*, students' belief in their ability to affect their own learning, has also been found to be related to SRL, with Zimmerman and Kitsantas (2005), for example, finding that self-efficacy predicted use of SRL strategies (e.g., organizing, memorization and rehearsal, monitoring) among adolescent girls. These two examples (out of too many to fully cover in this review) illustrate that the motivational component of SRL encompasses both self-beliefs such as self-efficacy or mindset, and regulation of emotions, such as delaying gratification. The latter appears less discussed but is of potentially significant importance to effective learning.

The reason for this is that motivation does not necessarily come naturally for learning tasks, and students may therefore need to regulate motivation and develop strategies to sustain or raise motivation in situations where they risk losing it (Wolters, 2003). One issue here is that motivation can have both a positive or negative association with learning and self-regulation. Boekaerts and Corno (2005) point out, for example, that self-regulation of learning is only one part of a given person's self-regulation, and that different forms of self-regulation may conflict. It may be, for example, that students emphasise self-regulation of well-being over self-regulation of learning, and thus make less rather than more effort in completing learning tasks. Students therefore need to regulate their motivational investment in learning activities, not least because they are often confronted with a choice between immediately rewarding activities and activities that may seem less so but that support longer term learning goals. Resolving this process in favour of the latter requires self-control, which is itself a metacognitive process that, according to Duckworth et al (2014) consists of strategies through which learners can control the learning process and enhance motivation:

(1) *Situation selection* and *situation modification* which involves choosing or changing physical or social circumstances,
(2) A*ttentional deployment* and *cognitive change* strategies which involve altering whether and how objective features of the situation are mentally represented, and
(3) *Response modulation* strategies which involve the direct suppression or enhancement of impulses.

These are again not necessarily strategies that children spontaneously develop, so they will need to be taught. Discussion remains as to whether this should happen through direct instruction or other methods such as modelling.

The role of emotions is currently receiving some research interest in the field, with Norman and Furnes (2014), for example, suggesting the existence of meta-emotion, which in parallel to metacognition consists of three facets, metaemotional experiences, metaemotional knowledge, and metaemotional strategies. Empirical evidence for this construct remains limited to date, however.

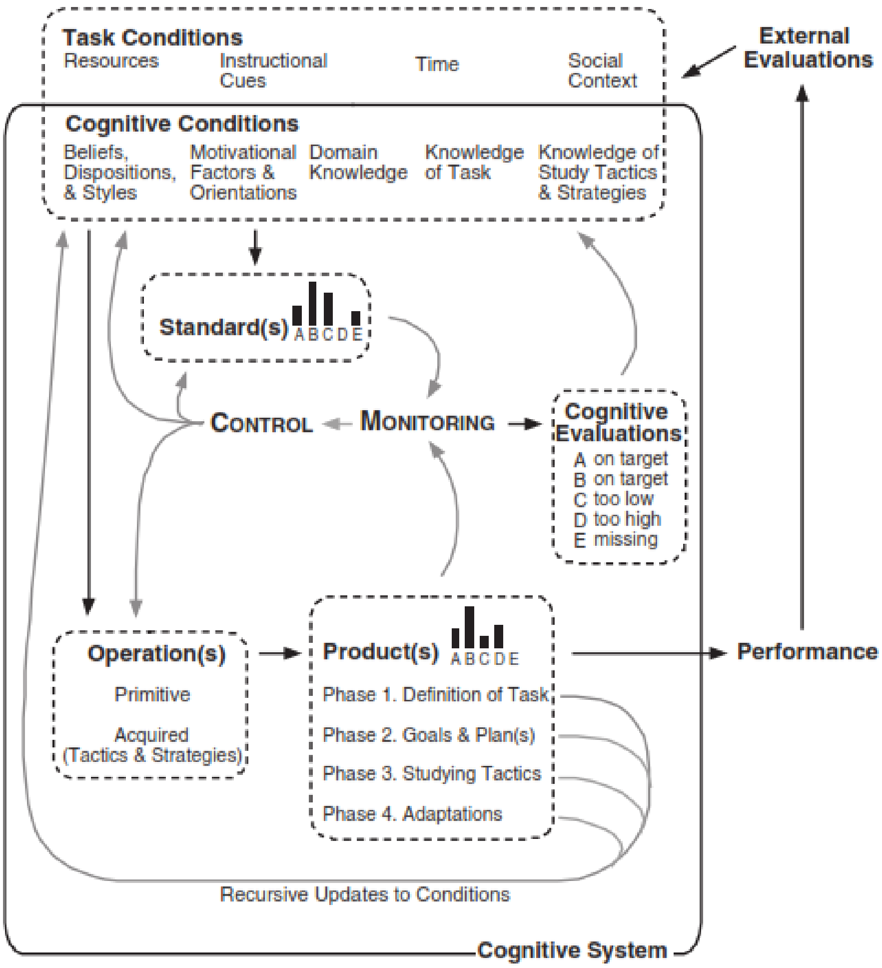
Wynne and Hadwin's integrated model

A theoretical framework that integrates all the above elements of metacognition and attempts a more fine-grained analysis of the processes of learning is the influential Wynne and Hadwin (1998) model (see figure 3). This model suggests an interaction between conditions under which learning takes place, standards, tasks, monitoring and control and feedback. Wynne and Hadwin distinguish four phases in the learning process:

(1) Task definition,
(2) Planning and goal setting,
(3) Selecting and using studying tactics, and
(4) Adapting the task activity as a result of feedback.

These phases are similar to those posited by Zimmerman (2001), who distinguishes a forethought phase, which includes planning, goal setting and self-motivation beliefs, a performance phase, including strategies, self-control and self-observation, and a self-reflection phase that includes self-evaluation, causal attribution and self-reaction (e.g. satisfaction).

Figure 3. Wynne and Hadwin's (1998) model of self-regulated learning.



In this model, *conditions* are the resources available to the learner. *Task conditions* include time to do the task, and resources (such as learning materials) the learner can draw on. *Cognitive conditions* are internal, and include the learner's motivation, prior knowledge of the task (including its difficulty), and not least knowledge of the subject domain. *Standards* are the criteria the learner believes represent an optimal state in completing the task. These include crucially standards set by teachers or external evaluations, but also the learner's own beliefs about what the standards are. *Operations* refer to the information processing that is key to learning, and includes searching, monitoring, assembling, rehearsing, and translating. This is the cognitive component of learning. Operations lead to *products*, which differ by phase of learning (see above). The metacognitive part of the model is the control and monitoring of the activities (as in Nelson and Narend's model). Importantly, in this model the process is influenced by both performance on the task and external evaluation (for example tests).

This model has been influential, and usefully gives us a more comprehensive view of learning, with most elements of the model having gained empirical support (it is hard to study the model as a whole). However, it has been criticised for being a rather individualistic model, and it does tend to refer to specific tasks rather than longer term learning outcomes. The model also lacks an understanding of how learning and metacognition may differ between individuals and life stages (Greene & Azevedo, 2007). It is in particular the individualistic and task-centred nature of the model that are problematic in terms of guiding classroom practise.

The context-specific and social nature of metacognition

While previous models may lead one to suppose that self-regulated learning and metacognition are relatively stable characteristics of an individual learner, this is not necessarily the case. A key distinction to be made is that between the more or less stable person characteristics involved and the task-specific characteristics on which the person characteristics act and with which they interact. This is an important distinction, as, for example, the monitoring of a particular task can change an individual's motivation, or the metacognitive strategies they bring to bear on the task. For example, a learner may start a task believing it will be easy to solve, but when doing it may experience feelings of difficulty and give up on it (Efklides, 2011).

Importantly, SRL and metacognition have been found to be quite context-dependent, which means that a student who shows strong SRL and metacognitive competence in one task or domain may be weak in another, and metacognitive strategies may be differentially effective depending on the specific task, subject or problem tackled (Hadwin & Oshige, 2011; Kim et al, 2013).

This has two consequences: firstly, transfer across subjects and domains is by no means automatic, and, secondly, as procedural knowledge requires strong domain knowledge, SRL and metacognition are stronger where the student has a strong grounding in subject knowledge in a particular area. Different domains and subjects differ with respect to the nature of instructional tasks and the structure of their subject matter which will inevitably influence how students regulate their own learning. There is, however, a lack of research on subject-related differences, though most empirical research has taken place within very specific domain and subject areas (most often maths, science and literacy), and these do suggest differences in effective approaches, albeit that the general frameworks appear to hold (Poitras & Lajoie, 2013). In the past there has been much discussion on whether or not SRL is a person or task characteristic (Martin & McLellan, 2007). But the evidence increasingly suggest it is in fact both.

SRL is also a social rather than a purely individual and internal process. Inter-subjectivity, or the relation between individuals, has been found to be central to the development of metacognition (Brinck & Liljenfors, 2013). Modelling by adults is a key way in which children develop self-regulation, and teachers can successfully demonstrate and model (context-specific) metacognitive strategies, providing feedback and scaffolding to develop it, and act as knowledgeable others in the sharing and developing of self-regulation. Interactions with others are one way to test one's own metacognitive strategies and knowledge, so both peers and teachers have a role to play here. This co-regulation of learning is also important to developing effective self-regulation in group and collaborative settings, where learners may need to develop s*ocially shared regulation of learning* (SSRL) in which group members regulate their collective activity through shared regulatory processes, beliefs and knowledge (Hadwin & Oshige, 2011; Jarvela, 2015).

According to Kim et al (2013), the learning environment develops metacognition both through individual sources (the individual's conceptual system) and social sources (the others' conceptual systems) which interact to develop metacognition. As such, group members as a whole will exercise monitoring and control over the process of learning towards a particular goal. This, however, should not be equated to seeing metacognition as a collective property, rather it is individuals using metacognition collaboratively to reach a group goal. In terms of Winne and Hadwin's model, social metacognition in the enacting study strategies phase, where it takes the forms of co-construction of knowledge, negotiation of meaning, and building of a common ground. However, much group work never reaches metacognitive sharing, as what is shared are operations and products of learning but not the standards and conditions, evaluation, monitoring and controlling of the learning process. (Schoor et al, 2015).

What does an able metacognitive learner look like?

Key to effective metacognition is the ability to monitor and regulate learning, to deliberately select the most effective strategy to approach a learning task, and to adapt that strategy based on feedback regarding the effectiveness of the learning engaged with. This means that there is no simple definition of an effective metacognitive learner, as the strategies and approaches used will depend on the subject, domain and task. Nevertheless, authors have attempted to list particular behaviours that one would expect metacognitive learners to engage with. For example, effective metacognitive learners are said to self-evaluate, keep records and monitor learning, ask adults for help, self-verbalise, set goals and plan progress, manage time, engage in learning from peers, show persistence and resilience and avoid distraction, seek out resources out of the classroom, give self-rewards or sanctions based on outcomes, memorise and rehearse information, and are aware of their own weaknesses (Clark & Dumas, 2016). Effective learners use a number of strategies, including setting specific proximal *goals*, adopting powerful *strategies* for attaining the goals, *monitoring* performance for signs of progress, *restructuring* one's physical and social context to make it compatible with one's goals, managing *time use* efficiently, *self-evaluating* one's methods, *attributing* causation to results, and *adapting* future methods (Zimmerman, 2010).

Being an effective metacognitive learner is also intricately linked with the motivational aspect of self-regulated learning, in that motivational factors are related to both cognition and metacognition. In one study of primary school children in grades 1 to 2, self-concept in grade 1 was positively related to metacognitive monitoring in grade 2, and grade 2 self-concept was likewise positively related to metacognitive monitoring in grade 1 (Roebers et al, 2012). It would not be accurate to draw a causal direction from this study, however, as metacognitive monitoring (and control) were not measured in grade 1.

Being an effective learner is also strongly related to how one reacts to failure and feedback on errors. Effectively using feedback and adapting has two main components, according to Grassinger and Dresel (2017): an affective-motivational component and an action adaptive reactions component. The affective-motivational adaptivity to error is defined as the degree to which a learner maintains positive affect and motivation to learn in the face of errors, while action adaptive reactions are defined as the degree to which a learner initiates cognitive processes and behaviours aimed at overcoming a possible misconception underlying the error they have made. In their study of 479 German secondary school students Grassinger and Dresel (2017) found both components to be strongly related, with 47% reacting adaptively on both dimensions, and 44% reacting maladaptively on both. Only 9% were positively adaptive on the motivational component, and negatively on the action component. This again points to the connectedness of motivational and cognitive components of self-regulation.

Zimmerman (2010, pp. 65-66), gives a nice description of what an able self-regulated learner looks like:

> *'These learners are proactive in their efforts to learn because they are aware of their strengths and limitations and because they are guided by personally set goals and task-related strategies, such as using an arithmetic addition strategy to check the accuracy of solutions to subtraction problems. These learners monitor their behavior in terms of their goals and self-reflect on their increasing effectiveness. This enhances their self-satisfaction and motivation to continue to improve their methods of learning.'*

Strength of evidence. In terms of the evidence a lot of the material reviewed here is theoretical, so doesn't fit the criteria as clearly as empirical studies. We have, for empirical data, not had to go below level 4, which suggests that the evidence is extensive. There also appears to be a growing consensus on the key characteristics of SRL and metacognition.

2. The development of metacognition

Early development and progression

Veenman et al. (2006, p. 8) state that until recently there was a general consensus that metacognition is a relatively late-developing capability, emerging at the age of 8-10 years, and expanding quite rapidly during the years thereafter up to around the age of 15. Moreover, certain metacognitive skills, like monitoring and evaluation, appear to mature later than others such as planning. Whitebread et al (2009), however, consider this an increasingly untenable position. They argue that even very young children (below 6 years of age) may reveal elementary executive functions that are closely related to metacognition. Moreover, younger children can predict and evaluate their own performance more accurately than older children when the tasks are ecologically valid and meaningful to them. Younger children also can engage in strategic behaviours in the context of meaningful and age-related tasks. According to Whitebread et al (2009) young children's metacognitive skills are often obscured by their lack of their verbal abilities to respond to hypothetical questions or to report on their own metacognitive activities, though verbalisation itself has also been linked to the development of metacognition (Clark & Dumas, 2016).

Recent studies, though admittedly limited in number and suffering from some of the methodological issues identified by Whitebread in terms of measuring metacognition at young ages, suggest that the view of early onset of metacognition is supported. In particular, procedural metacognition develops early, with children as young as 3 being able to opt out of tasks based on their understanding of ease of task and level of uncertainty. Children can thus both judge their own level of certainty about a task and use this to decide on whether to engage in it. They also show greater accuracy on tasks they accept to do than on tasks they don't (Bernard et al, 2015). It is also clear that children at an early age start to develop what is known as *Theory of Mind* (ToM), which is the ability to impute mental states such as beliefs, desires, and intentions to oneself and others in order to explain and predict behaviour. ToM is a key precursor of metacognition, as illustrated by the emergence of the ability to realise that people can hold mistaken beliefs which emerges at around 3-4 years of age. The extent of development of ToM at age 3 has been found to be a predictor of reading comprehension at age 6 (alongside decoding skills and linguistic competence) in at least one study (Atkinson et al, 2017). Not all studies show similar effects, and there is clear evidence that the level of security and self-knowledge remains rather inaccurate until about 8 years of age, with children being overoptimistic about their levels of knowledge (Clark & Dumas, 2016), but the overall trend suggests forms of metacognition emerge early on in the lifespan. According to Brinck and Liljenfors (2013) the origins of metacognition lie in the infant's interaction with others, which allow the infant to first experience and then respond to the other's reactions. In this way they start to develop early onset of monitoring and control skills during the crucial 2-4 months developmental stage. An important part of early metacognitive development is therefore co-regulation, where the child develops self-regulation by sharing practices and thinking with a more knowledgeable other (e.g. a parent) (Hadwin & Oshigo, 2011).

Though metacognition emerges among children quite early on, different aspects develop at different rates. First to develop is Theory-of-Mind, which emerges between 3 and 5 years of age (Lockl & Schneider, 2006). By about age 3 (children of course differ in their developmental trajectory), children have some awareness of themselves as knowers, and can distinguish between thinking about an object from actually perceiving it, and they start to use words like 'think'. By around age 4 they are able to understand that others also have thoughts and beliefs, and that these may differ from their own (Kuhn, 2009). From around 5 to 8 metamemory and metacognitive knowledge first start to emerge (Alexander et al, 1995), and metacognitive skills start to develop between 8 and 10 (Veenman et al, 2004; 2006). However, children of this age still show little awareness of mistakes and adaptability without adult assistance (Pappas et al, 2003). Some declarative knowledge such as factual knowledge of different strategies, already exists in preschool. It develops rapidly once a child enters formal schooling, and continues to develop reasonably linearly at least into early adulthood, with even adolescents and young adults lacking knowledge about some powerful and important memory strategies (Schneider, 2008)). The same is true of metamemory, the start of which emerges early on. Young children (3 years and below) have some metamemory skills, but they have difficulty understanding the many influences on memory and find it hard to monitor their own memory. They also find it hard to choose which strategy to use. When confronted with a sorting task, for example, they find it hard to decide whether to use a shape or colour rule, notwithstanding that they have mastered both (Zelazo & Fruye, 1998). Metamemory develops over time, but instruction can enhance and speed up the process (Karably & Zabrucky, 2009). Planning appears to emerge sooner than monitoring and evaluation, and monitoring earlier than control (Pappas et al, 2003; Bryce & Whitebread, 2012). In one study of 133 children, for example, it was found that by age 9 children had developed good monitoring skills, and could reliably distinguish between correct and incorrect answers in a test-taking task. However, in terms of control 11- and 12-year-olds were better able to improve their performance by selectively withdrawing answers that would have been incorrect than the 9- to 10-year-olds (Roebers et al, 2009).

Veenman et al (2006) conclude that it is likely that metacognitive knowledge and skills already develop at a very basic level during pre-school and early-school years, but become more sophisticated and academically oriented whenever formal education requires the explicit utilization of a metacognitive repertoire. Furthermore, metacognitive skills seem initially to develop in separate domains and later on become generalized across domains (Veenman & Spaans, 2005).

Quantitative or qualitative development?

A number of questions remain somewhat unresolved in the field of development of SRL and metacognition. One of these is the extent to which development occurs linearly. Veenman et al (2006) argue that metacognition develops along a monotonic incremental line through the school years, parallel to the development of intellectual abilities. Others. However, disagree, claiming these developments do not follow a clear linear progression. Results of a number of studies suggest that most forms of metacognition which appear present in at least an embryonic form in early years simply become more sophisticated over time (Pappas et.al, 2003; Whitebread, 1999). According to Kuhn (2000), the development of metacognition does not go in stages, rather there is a shift from using a lesser to a greater number of metacognitive processes and strategies over time (Kuhn, 2000).

A second question that has been seen as hard to answer in terms of the development of metacognitive skills is whether development is primarily quantitative (i.e. children do more of the same), or qualitative (i.e. do children develop different and more sophisticated skills). In children from ages 5 to 7, Bryce and Whitebread (2012) developed an observational method to study 66 English children during a problem-solving task involving construction of a rail track. Results suggested both higher rates of monitoring and control among the older children as qualitative changes, in that types of monitoring used differed between the older and younger groups, with older children 50% more likely to check their plans, and younger children more likely to check their construction. There were also differences in planning behaviours, in that young children’s planning was explicitly stated, whereas older children’s planning was reflected in more internalized preparatory behaviours.

The role of instruction

Children will develop SRL and metacognition through maturation, interaction and imitation of adults and older learners whether or not they receive targeted instruction in metacognition. Most students develop metacognition spontaneously, picking it up from their parents, peers, and teachers, but there is considerable variation between students in their level of metacognition, and a relatively large group of students does not acquire a sufficient level of metacognition, due to a lack of opportunities, role models, or effort put into acquiring it.

As with other aspects of knowledge and skills, this means that they will develop differentially, with the extent to which skills are acquired in part dependent on the opportunities they receive to develop these skills in the home, which is likely to be correlated with social background (Veenman et al, 2006). There is corroborating evidence that the acquirement and use of metacognition is dependent on gender and socioeconomic background, to the advantage of females and students from culturally-rich environments (Leutwyler, 2009). Not all children will automatically develop metacognition, and it is for these children, and especially those from less stimulating backgrounds, that instruction is most important. Instruction can also help develop more effective metacognition faster than relying on spontaneous development. In part, developing metacognitive skills is about increasing processing fluency, the experienced ease with which a mental operation is performed, which will increase as domain knowledge and metacognitive skills increase, and lead to greater speed in processing and greater feeling of ease as well as more accurate judgements of knowing (Reber & Greifeneder, 2017). As metacognitive skills and self-regulation develop and strengthen over time, authors have suggested that the relationship between SRL and achievement is likely to be stronger in the later (i.e. secondary) years of schooling than in the primary years, though in their meta-analysis Dent and Koenka, (2015) actually found stronger correlations in primary schools than in middle and high schools.

Strength of evidence. There is a growing evidence base on the development and the developmental origins of metacognition. However, the field still contains contradictions, not least due to the difficulties in developing valid methodologies. For this reason we have had to review papers with a *moderate* strength of evidence and above.

3. Is there any evidence that disadvantaged groups have lower levels of self-regulatory skills and/or benefit more from interventions to improve self-regulatory skills?

Social disadvantage and the development of SRL/metacognition

The research base on differences between disadvantaged and non-disadvantaged groups in SRL and metacognition, or at the role of DRL and metacognition in closing attainment gaps between disadvantaged and non-disadvantaged pupils, is somewhat limited.

There has been speculation that lower attainment among pupils from disadvantaged backgrounds may result from lower levels of self-regulation and metacognition, and that developing metacognition might significantly aid underachieving students, who in some studies have been found to not so much not possess cognitive strategies as be deficient in using them (Carr et al, 1991). Veenman et al (2006), for example, found that lower performing students used fewer cognitive strategies, even where several more had been modelled for them, while higher achieving students used all modelled strategies (though of course the issue may be the use of modelling rather than instruction in the strategies). Empirical evidence of this remains limited, however.

Notwithstanding the relatively limited number of studies and the oft-found methodological limitations in the studies that do exist, there is some communality in the findings of studies that have looked at differences between pupils from more or less socio-economically disadvantaged backgrounds. One reanalysis of the PISA dataset showed that amongst secondary age students there is a modest correlation between SES and use of (self-reported) metacognitive strategies, with pupils from higher SES backgrounds using them more (Callan et al, 2016). A study of lower primary aged pupils in Australia found a modest positive relationship between socio-economic status background and scores on a self-regulated learning measure (Daniel et al, 2016), with similar findings reported in secondary (Oliver & Venville, 2016), and similarly modest correlations found among early years pupils (age 3 and 4) in the US (Blankson et al, 2016). Another reanalysis of PISA 2009 looked at differences between low SES pupils who did well on reading attainment (known as disadvantaged resilient students) and low SES pupils who did not do well on reading attainment in four Asian countries. One distinguishing factor between the two groups in all four countries was metacognitive awareness of reading strategies (Cheung et al, 2013). SES differences in metacognitive skills seem to emerge at an early age. In one study observing 102 children ranging aged 4-6 months in in New York City it was found that the ability to describe thinking and explain ideas was stronger in the upper-SES group than the middle- or lower-SES group (Pappas et al, 2003). Leutwyler (2009), reviewing the evidence, also reported modest correlations between social background and metacognitive development. As such, the best evidence suggests that development of metacognition and SRL is related to social background, but that the relationship is no more than modest.

In terms of intervention, there is evidence that some, though not all, programmes targeting improved SRL and metacognition can be successful with pupils from low SES backgrounds. Donker et al (2014) in their meta-analysis found slightly stronger effect sizes .7) for low SES and ethnic minority students than for so-called 'regular' students (.6), but the same was true for gifted and high SES (also .7). There is, however, less evidence that they have a greater impact on these students. One intervention study aimed at improving metacognition that did show improvement in attainment among low SES and minority ethnic group students but not among their high SES and majority counterparts was conducted using a moderately strong RCT design with almost 300 grade 9 pupils in the US. However, self-reported use of metacognitive strategies did not improve in either group following the intervention (Andrzezejewski et al, 2016). An Australian programme saw greater gains from a thinking skills programme in schools serving more disadvantaged communities (Oliver & Venville, 2016).

A useful source of evidence in this area are the evaluations conducted by EEF, as they all include specific analysis of the performance of pupils eligible for Free School Meals. The picture, however, is once again mixed. A primary intervention aimed at developing higher order skills in science saw a greater positive impact for pupils eligible for Free School Meals than for those not eligible (Hanley et al, 2016). The same was true of a primary intervention in literacy 'Self-Regulated Strategy Development' (SRSD) to help struggling writers in Years 6 and 7, where again the positive impact was greater for FSM pupils (Torgerson et al, 2014). On the other hand, an intervention to develop growth mindsets among primary 5 pupils in England (the 'Changing Mindsets' programme), showed no significant impact overall, and lower effects on pupils eligible for Free School Meals than on those not eligible (Rienzo et al, 2015). Another intervention in England which trained teachers in year 4 to embed metacognition in their instruction and involve parents showed no overall significant effects on attainment, but did show improved scores on measures of metacognition in the treatment group overall, and there was no evidence of these results being different for FSM pupils (though the evaluation suffered from a number of methodological problems (Dorsett et al., 2014)). A primary metacognitive intervention programme saw pupils in the treatment make four months more average progress in maths, but this was only two months for FSM eligible pupils. In English the control group outperformed the treatment group (Motteram et al, 2016).

There is therefore little evidence in this area with most of what we know being limited to the finding that various interventions aimed at SRL and metacognition have successfully taken place in schools serving disadvantaged pupils (e.g. Adey et al, 2002), suggesting that these pupils are certainly able to benefit from metacognitive development, but as yet no convincing evidence that pupils from disadvantaged backgrounds benefit more than those from more advantaged backgrounds, and there is thus at present no evidence that such programmes are likely to close attainment gaps between these groups.

Other student characteristics

As well as looking at socio-economic disadvantage, there are some studies that have compared pupils with other specific characteristics.

Unsurprisingly, studies on both pupils with learning difficulties or lower attainers more generally show that these pupils have lower levels of SRL and metacognition (Desoete & Roeyers, 2005; King & McInerney, 2016), but do not necessarily suggest a different pattern or strength of relationships between SRL and attainment. Furthermore, in reanalysing their data Desoete and Roeyers (2006) found that while 4 out of 5 pupils with learning difficulties in their study of third graders had low metacognitive skills, the same was true of 1 in 5 of the non-LD students. However, while most pupils with low metacognitive skills mainly had problems with prediction (e.g predicting the difficulty of tasks), those with LD also had problems evaluating. In terms of interventions, Donker et al's (2013) meta-analysis of learning strategies interventions suggested no differences in effectiveness by students' ability levels. There is some evidence that metacognitive training can aid students with learning difficulties, Losinski et al's (2014) meta-analysis, for example, finding that self-regulated strategy development can improve the writing skills of students with emotional and behavioural disorders.

Some studies show girls performing higher on self-regulated learning than boys, and this finding seems to reoccur across phases and countries (Daniel et al, 2016, Blankson et al, 2016, Kolic-Vehovec, & Bajsanski, 2006; King & McInerney, 2016). There is, however, again little evidence that the structure of relationships between metacognitive skills and factors such as attainment or goal mastery differ between genders.

Some studies have looked at differences between native and non-native speakers. For example, Andringa et al (2012) studied listening comprehension among upper secondary school native and non-native speakers of Dutch in the Netherlands, and found some differences in that listening comprehension among native speakers was predicted by knowledge of the language and the efficiency with which they could process linguistic information, while for non-native speakers it was predicted by knowledge and reasoning ability. Similarly, in a study of grade 5-8 pupils in Italian medium schools in Croatia, bilingual students with high perceived proficiency in Italian had better meta-cognitive reading skills than those with low perceived proficiency in Italian (Kolic-Vehovec, & Bajsanski, 2007).

Strength of evidence. The evidence base in this area is moderate at best. The volume of research is not great, and many of the studies reviewed are of only moderate strength, with sample sizes often quite small to look at group differences (e.g. typically in the low hundreds), many use convenience samples, and in e.g. the reanalyses of PISA studies insufficient attention paid to data structures.

4. Assessment of metacognition and self-regulation skills

Measuring metacognition and SRL is a challenge identified by many authors and researchers in the field (e.g. Dent & Koenka, 2015; Veenman et al, 2006). It is hard to disentangle cognition and metacognition in terms of measuring them (Veeman et al, 2006), though sometimes they can be inferred from successfully completing cognitive activities, and it can be hard to get accurate reflection on metacognitive strategies from learners.

Dinsmore et al (2008), in their overview, found a range of measures used to study metacognition and SRL (see Table 2).

Table 2.
Frequency and Percent of Measurement Type by Construct (from Dinsmore et al, 2008)

Measurement type	Metacognition		Self-regulation	
	f	**Percent**	***f***	**Percent**
Self-report	29	24	37	73
Observation	24	20	10	20
Think-aloud	14	12	00	00
Interviews	16	13	02	04
Performance ratings	38	31	01	02
Diaries	00	00	01	02

The table shows a strong reliance on self-report for SRL but much less so for metacognition, where performance ratings such as tests, observational methods, interviews and think aloud protocols are also used.

Overall, then, traditionally most use has been made of retrospective student self-report measures, usually in the form of questionnaires, but though easy to administer to large groups these have been criticised on grounds of reliability and validity, with scores on such questionnaires often showing low correlations with behavioural measures taken during task performance. Part of this is due to the difficulty of post-hoc recall from memory of metacognitive behaviours during a task, with a further complication being that students with higher metacognitive skills levels may be better at discerning their own use of metacognitive strategies retrospectively, and may in fact be less likely to use generic and more likely to use domain and task specific strategies, thus reporting lower scores on generic measures of metacognition in some cases (Veenman et al, 2006; Dent & Koenka, 2015).

Structured interviews reduce bias inherent in surveys, as they typically describe a hypothetical learning scenario and ask students to describe how they would use self-regulated learning strategies during it, thus allowing them to access more context-specific strategies (Dent & Koenka, 2015). They are however harder to implement and do not easily lend themselves to use with large samples; furthermore, they are still susceptible to self-report bias and issues of retrieving strategy use from memory.

For these reasons, researchers have advocated the use of real-time rather than retrospective measures, collecting indicators of self-regulation as students are completing a particular task. Two main types are identified in Dent and Koenka's (2015) review: traces and think aloud protocols.

Traces are observable signs of cognitive strategies students use while completing a task, such as underlining a passage or making notes alongside a piece of text. These are not reliant on self-report, but have their own inherent biases and issues, such as the fact that it is not easy or even possible to establish metacognitive processes underlying these cognitive strategies, and that such strategies may themselves be used rather unthinkingly where students are taught or expected to do so by teachers.

Think aloud protocols ask students to express their thought processes while doing a particular task, so again one doesn't rely on retrospection. However, they are still a self-report measure with all the issues that come with those, and may be biased by students' literacy, and depending on method used, verbal or written language strengths and abilities. Students may find it hard to articulate their thoughts while doing a task, and doing so may interfere with task performance, which again may be more strongly the case for some students than others thus introducing further bias (Dent & Koenka, 2015). A variation of this method is to use *learning journals,* which were found to be good measures of use of cognitive and metacognitive strategies, and predictive of attainment, in one study of over 250 German secondary schools students (Glogger et al, 2012).

Whitebread et al (2009) argue in favour of direct observational methods that look at learners while they are completing a task and estimate their use of metacognition directly. These have the advantage that they record actual learner behaviours, which allows observers to take nonverbal behaviours to into account and record social interactions between learners. They are also less reliant on verbal or language skills, which makes them more suitable for measuring young learners of those with limited language skills.

Assessment during task performance appears to be more predictive and accurate than assessment before or after task performance (Veenman et al, 2006), with Dent and Koenka (2015) finding an average correlation of measures during task with achievement of .39, and an average correlation of post-hoc measures of .15 in their meta-analysis of 61 studies.

Part of the development of measures of self-regulation has followed changes in our knowledge and understanding of the processes involved. Thus, as it has become clearer that SRL and metacognition are domain and task-specific, generic instruments have largely been replaced by subject or task specific ones (Dent & Koenka, 2015).

A key question for educational practise is of course the extent to which teachers are able to assess their pupils metacognitive and self-regulation skills reasonably accurately. Results here are somewhat mixed. One German study of over 1000 high school students and their teachers found that teachers (N=73) were able to distinguish between self-regulation skills, general competence of students in maths and their self-concept, but that their ratings were only moderately related to students' self-ratings, in particular in the area of self-regulation (Friedrich et al, 2013). Similarly, a study of grade 3-9 students in the US found low correlations between teacher ratings and student test measures of metacognition (Sperling et al, 2002). A US study of a middle school, on the other hand, did find moderate correlations between student and teacher ratings in Science (Sperling et al, 2012).

Overall, then, the measurement of metacognition and SRL is complex, and no optimal method exists. Assessment during task performance appears to be more accurate, but limits options for large-scale studies and studies that intend to look at metacognition across broader domains. Teacher assessments of their students appear moderately accurate.

Strength of evidence. The evidence in this area was collated from studies from a moderate level of evidence onwards.

Section 2: How can these skills be improved, and what impact does this have on attainment?

5. Does improving metacognition/self-regulation lead to improved attainment outcomes?

There is extensive evidence that metacognition is related to attainment, though this is of course not quite the same as stating that improving metacognition will lead to improved attainment, as most studies are cross-sectional, meaning that it is hard to draw causal conclusions.

Cross-sectional studies

Various studies have established that SRL, and in particular metacognition, has a significant albeit in most studies moderate, relationship with students' academic performance, on top of ability or prior achievement, and this is found across national contexts and school phases (e.g. Hacker, Dunlosky, & Graesser*,* 2009; Ponitz et al, 2008; Pressley & Harris, 2006; Broekkamp et al, 2002; Ciascai & Haiduc, 2014; Fadlelmula et al, 2015; Kaya & Kablan, 2008; Swalander & Taube, 2008). Veenman et al (2004) and Veenman & Spaans (cited in Veenman et al., 2006, p. 6) found that metacognitive skills and intelligence are moderately correlated. On average, intelligence uniquely accounts for 10% of variance in learning, metacognitive skills uniquely accounts for 17% of the variance, whereas both predictors together share another 20% of variance in learning for students of different ages and background, for different types of tasks, and for different domains. The implication, according to Veenman et al (2006), is that an adequate level of metacognition may compensate for students' cognitive limitations.

These correlations between metacognition and learning outcomes appear to hold when other key variables are controlled for. For example, in one large-scale German study on reading comprehension among 15-year olds, metacognitive knowledge, decoding speed, and the number of books at home were found to be the main predictors of scores on online reading comprehension tests, with the strongest predictor being metacognition (Artelt et al, 2001). Similarly, in a reanalysis of PISA 2009 data, use of metacognitive strategies which involve an awareness of thinking, as measured by the appropriate use of strategies within a context, were related to greater achievement. Although there were differences across gender and student SES, metacognitive strategies remained a significant predictor of achievement when controlling for SES and gender, and were on par with SES in predicting attainment (Callan et al, 2016).

Not all aspects of SRL and metacognition show the same level of correlation with attainment, however. Dent and Koenka's (2015) meta-analysis suggests that while planning, metacognitive strategies, self-checking and adjusting have moderate correlations with attainment, keeping records and goal setting are much more weakly related to attainment. Generally, though they found that combined measures of metacognition and SRL had the strongest relation to attainment of all the variables in their analyses, suggesting that it is important to focus on the process as a whole and not single elements thereof. Strategy development was found to have a moderate to large effect in de Boer et al's (2014) meta-analysis, with in particular interventions focused on task value, and to a lesser extent general metacognitive knowledge and planning having positive effects, while interventions focusing on goal orientation had a negative correlation with attainment. Not all studies show positive correlations between SRL/metacognition attainment, one Austrian self-report survey of over 5000 secondary school students found that some cognitive strategies were positively, but others negatively related to attainment, and that self-reported use of metacognitive strategies was also negatively related to attainment (Klug et al, 2016). In particular, correlations between measures of metacognition and attainment are low in some studies (Muis et al, 2007; Neuenhaus et al, 2011), which may be a result of the difficulties in measuring metacognition using traditional paper and pencil tests (see previous section of this report). Where significant correlations are found, as in the majority of studies, correlation of course does not necessarily imply causation, with one study of over 8000 secondary students in Hong Kong suggesting that higher attainment leads to improved metacognitive strategy use rather than the other way around (King & MicInerney, 2016). Thus it is important to look at studies that have carefully been designed to look at change over time or at interventions where the impact of SRL and metacognition can be more validly measured.

Longitudinal studies

Studies that have longitudinally sampled SRL and metacognition and looked at subsequent effects on attainment are limited in number. One study on the relationship between prior metacognitive skills on later attainment in reading was conducted by Atkinson et al (2017). In their study 80 children were tested for Theory of Mind (ToM), decoding, language skills, and executive function (EF) at age 4 and for word reading efficiency, language skills, and reading comprehension at age 6. Results showed that ToM at time 1 predicted time 2 reading comprehension controlling for the other variables. Similar results were found in Finland, where children's letter knowledge, meta-cognitive awareness, gender, mother's level of education, and visual attention at the beginning of kindergarten predicted their reading skills at the end of Grade 4 in a study of 1456 children (Leppanen et al, 2008). A study of maths learning for a similar age group in Finland showed similar results, with metacognition at age 3 predicting mathematics performance at age 6, and indirectly predicting rate of growth of mathematics performance between ages 3 and 6 (largely through the effect of metacognition on counting ability, which in turn affected mathematics performance) (Aunola et al, 2004). Other predictors were meta-cognitive awareness, gender, mother's level of education, and visual attention. Phonological awareness at kindergarten affected reading skills at Grade 4 through reading skills in kindergarten and Grade 1. Another study of young children, this time in the US, likewise found that emotion regulation, executive functioning, emotion knowledge, and metacognition at ages 3 and 4 predicted achievement at age 5 (Blankson et al, 2017).

A study in German secondary schools used learning journals which students wrote for 6 weeks to predict subsequent mathematics attainment. The researchers found that quality and quantity of cognitive strategies predicted learning outcomes, controlling for prior knowledge. Learners who combined cognitive plus metacognitive strategies were particularly successful. It was found to be important that learners used several cognitive strategies, use of one strategy alone did not lead to better performance than using none. Similar findings were reported in a replication study on Biology (Glogger et al, 2012). A large-scale panel study of Dutch secondary school pupils conducted between years 1 and 5 of secondary school found that long term educational attainment was predicted by motivation, meta-cognition and self-regulation as well as student background variables and prior achievement (Kuyper et al, 2000).

Intervention studies

The results of intervention studies also suggest that improving metacognition can result in higher levels of attainment. In their extensive meta-analysis of the impact of interventions on SRL (which included cognition, metacognition and motivation), Dignath and Büttner (2008) reported a significant average effect on attainment (.69) which was similar in primary and secondary education, though effects did differ between subjects. They found that in primary schools, effect sizes were highest if the intervention was based on social-cognitive theories, medium if they were based on metacognition, and lowest if they were based on developing motivation. However, interventions which included instruction of metacognitive strategies and motivational strategies alongside cognition showed larger effect sizes than those that didn't. Interventions involving group work were less effective. In secondary, interventions based on metacognition were most effective, and interventions focusing on metacognitive reflection were more effective than those focusing on motivation or cognitive strategies. Interventions focusing on metacognitive strategies showed the lowest effects. Interventions appeared to have a stronger effect on maths in primary and on reading in secondary. A similar strength of effect was found in Higgins et al's (2005) synthesis of research on thinking skills interventions. In Slavin's (2013) systematic review of studies on reading and mathematics in both primary and secondary schools, programmes addressing metacognition proved among the more effective approaches, and far more so than approaches aimed at curriculum reform and computer-assisted instruction, though this was only the case where programmes had been implemented well, with extensive teacher professional development provided.

An intervention to improve reading in an elementary school in the US showed significantly greater gains on a standardized state reading test (though not on an informal reading test) among pupils who took part in the intervention that included a metacognitive development component than among pupils in the control group, and non-significantly greater gains than pupils in an intervention group that included profile awareness but not metacognitive intervention. Sample sizes were relatively small, however (Allen & Hancock, 2008). An intervention to improve writing skills among 4th grade pupils in which they either received self-regulatory writing strategies training or were taught writing strategies without self-regulation procedures showed that teaching strategies in tandem with self-regulation procedures improved students' skills of planning and revising stories and enhanced the quality of the resulting stories.

Self-regulated learning also enhanced students' knowledge about good writing and strengthened their self-efficacy beliefs (Brunstein & Glaser, 2011). A focus on metacognition may improve the impact of other interventions. For example, a meta-analysis of the impact of writing effects on attainment showed that the effects of this type of intervention are improved where metacognitive reflection was used in which students were asked to reflect on their ongoing learning processes (Bangert-Drowns et al, 2004). In one high quality intervention study it was found that developing teachers own metacognition and SRL had a positive impact on pupil attainment (Heller et al, 2012).

The evidence suggests that interventions are stronger where they focus on several aspects of SRL and metacognition. Grassinger & Dresel's (2017) study demonstrated the importance of motivational factors and pupil goal setting to adaptation to errors, finding that among their sample of German secondary school students a positive ability self-concept, a strong pursuit of mastery goals, and internal-variable attributions to failure corresponded with adaptive reactions to errors and a strong pursuit of performance avoidance goals correspond with maladaptive reactions to errors. Including motivation as well as cognitive and metacognitive development was found to significantly improve the impact of a science intervention among 10th graders in Israel (Michalsky, 2013). Similar findings were reported in a study on the development of reading strategies among fifth graders, where again an intervention that combined cognition, metacognition and motivation outperformed conditions which did not include all three elements on strategy retention (Souvignier & Moklesgerami, 2006).

In summary, while not all evidence suggests a relationship between SRL, metacognition and attainment, the bulk of the evidence, and particularly that from intervention studies, does suggest that improving SRL and metacognition can lead to improved attainment. This is particularly the case where multiple elements of SRL are included. The strength of the relationship appears to be moderate in most studies.

Strength of evidence. The evidence for a relationship between SRL and metacognition and attainment is quite strong. All the studies reported here were of at least moderate strength of evidence, with the majority being of extensive strength of evidence. The great majority of studies point to a significant, positive, moderate relationship suggesting an emerging consensus.

In terms of directness the majority of the studies reported here have been conducted outside of the UK and primarily in continental Europe and the US. However, there are no compelling reasons to suggest that the fundamental relationships would differ substantially here. They cover the range of age groups, and cover the range of SRL. This would lead us to a rating of 2.

6. What types of metacognitive/self-regulated learning strategies are effective at improving outcomes?

There is extensive evidence that metacognition and SRL can be improved through educational interventions. Dignath and Büttner, for example, in their meta-analysis, found that interventions to improve SRL showed positive effect sizes in relation to pupils' strategy use following the intervention, with average effect sizes of .72 in primary and .88 in secondary. That SRL can be improved through education is not just true for metacognition, but has been found to be the case for other parts of SRL as well. For example, emotional self-regulation has been found to be improved through classroom level interventions around social-emotional learning (e.g. Smith et al, 2016; Muijs et al, 2016).

The key question then are what exact skills and knowledge learners need, and what forms of instruction are best suited to ensuring that learners acquire them. The former question will be discussed in this section, the latter in the following section of this report.

There are three key types of strategies included in self-regulated learning:

- *Cognitive strategies*, which are to do with the activities a student will undertake while learning, such as rehearsal, reviewing, retrieval practise and spacing;

- *Metacognitive strategies*, to do with the monitoring and regulation of learning, such as planning, deciding which strategies to use, monitoring how successfully a learning activity is going, and adapting strategies based on that assessment; and
- *Social-emotional strategies*, to do with regulating motivation and relations with others, such as delay of gratification, developing self-efficacy and help-seeking (Zimmerman, 1990; Veenman et al, 2006; Ardasheva et al, 2017).

These three elements are closely interrelated, and effective development of SRL should ideally address all three. Cognitive strategies are needed so learners have an array of means to address particular learning tasks such as memorization, but in order to effectively choose a strategy they will need to develop metacognitive strategies. They will also require sufficient motivation and perseverance to tackle the problem and apply the strategies in the first place. This interaction can be exemplified by a five-year study in Philadelphia primary schools, in which 10 treatment groups (8 controls) were given an intervention on conflict resolution and related social skill development, which was found to lead to improved metacognitive skills (Heydenberk & Heydenberk, 2005). Similarly, in a study in the Netherlands in which almost 500 grade 7 students were measured at three time points across a school year, growth curve analyses showed that changes in positive emotions were systematically associated with improvements in self-regulated learning and achievement (Ahmed et al, 2013). A two-year study of 300 9th graders meanwhile found that self-efficacy predicted use of learning strategies (though not the other way around) (Berger & Karabenick, 2011).

In terms of *cognitive strategies*, the three main types are:

- *Rehearsal strategies*, aimed repeating material for memorisation, e.g. spaced practice;
- *Elaboration strategies*, which focus on building connections in long-term memory by connecting new to existing knowledge, for example through paraphrasing; and
- *Organisation strategies* to help select information, for example by creating conceptual maps (Pintrich, 1991).

Metacognitive strategies are most commonly distinguished as:

- *Planning strategies*, such as making a plan or deciding how much time to spend on an activity;
- *Monitoring strategies*, used to check understanding and learning during a task, for example through self-testing and questioning;
- *Evaluation strategies*, used to analyse performance (Shraw & Dennison, 1994).

Metacognitive knowledge has in turn been described as constituting knowledge of:

- making generalisations and drawing rules regarding a thinking strategy;
- naming the thinking strategy;
- explaining when, why, and how such a thinking strategy should be used and when it should not be used;
- what the disadvantages are of not using appropriate strategies; and
- what task characteristics call for the use of the strategy (Ben-David & Zohar, 2009).

In Donker et al's (2014) meta-analysis, cognitive and metacognitive strategies showed significant positive effect sizes. These were similar in strength (moderate) with the exception of rehearsal strategies, which showed a stronger effect size. When combined in regression analyses, planning showed a stronger effect size than the other two dimensions of metacognitive strategies. This suggests that interventions should not just focus on one element, with Perry et al's (2012) meta-analysis of SRL interventions, for example, showing stronger effect sizes where interventions include both monitoring and strategy instruction than when they only include monitoring, and Glaser & Burnstein's (2007) study in Germany showing that 4th graders taught both self-regulation and compositional strategies outperformed groups taught only compositional strategies, while Mevarech et al (2017) showed that interventions including the development of cognition, motivation and metacognition had more positive effects than interventions focusing solely on motivation or on a combination of cognition and metacognition in primary mathematics.

As these strategies only partially develop spontaneously, and only do so in some students and not others, instruction in strategy use is essential.

Strength of evidence. While different categorizations exist, there is a moderately strong consensus among researchers in the field on the key elements of cognitive and metacognitive strategies.

In terms of directness, again the majority of studies were conducted in continental Europe and the US, but as they refer to general principles the level of directness is still quite good (2).

7. Teaching SRL and metacognition

The evidence suggests that effective teaching of SRL and metacognition has two main elements:

- The direct approach, through explicit instruction and implicit modelling by the teacher
- The indirect approach, through creating a conducive learning environment, with guided practise, including dialogue and (scaffolded) inquiry

Direct approaches

Direct approaches are deliberate actions to teach pupils SRL and metacognitive strategies. A key distinction made in the literature is that between implicit and explicit instruction of self-regulatory and metacognitive strategies, where implicit strategies refer to, for example, the teacher modelling a behaviour such as verbalising her thought processes without telling pupils why she is doing so, while in explicit teaching the teacher will tell the students that she is modelling a learning strategy, what it is and why it matters (Kister et al, 2010).

Explicit instruction

The key strategies mentioned in the previous section are not spontaneously developed, but require explicit instruction. Explicit instruction is not to be confused with a lecturing approach, but combines explicit teacher input with interactive questioning and feedback and a mastery approach to acquiring content (Brophy & Good, 1986).

Strategy instruction is a key part of the development of SRL and metacognition, and has shown significant effect sizes in meta-analytic studies, with de Boer et al (2014) reporting moderate to large effects depending on subjects (largest on writing, moderate on maths, science and reading)

Strategy instruction has most typically been done using a four-step procedure consisting of awareness raising (why do these strategies matter), modelling of the appropriate strategy, practise of the strategy and evaluation and goal setting. Research on the effectiveness of this approach does show some differential findings, with not all studies showing successful implementation.

However, in a meta-analysis of the impact of strategy instruction on language learning Ardasheva et al (2017) did report strong positive effect sizes on both the use of self-regulation strategies (.87) and language learning outcomes (.78), with the effect being larger for younger than for older learners. Cognitive and metacognitive strategies require explicit instruction with through explanation, modelling and guided practise (Allen & Hancock, 2008). While much of the research focusses on cognitive strategies, knowledge, both of cognition and metacognitive strategies, is equally important. Meta-strategic Knowledge (MSK) is a sub-component of metacognition that is defined as general, explicit knowledge about thinking strategies. One study of 8th graders showed strong effects on students' strategic and meta-strategic thinking following explicit instruction on MSK, especially for low achieving students. (Zohar & David, 2008).

In a study comparing the use of metacognitive training to worked-out examples in mathematics among 8th graders in Israel, pupils who had received metacognitive training did significantly better, both on a post-test and a delayed post-test the following school year (Mevarech & Kramarsky, 2003). The issue of overconfidence of the accuracy of responses observed in many learners (overestimated judgements of learning) has also been found to be amenable to the inclusion of explicit standards. In one study researchers providing various standards to middle school students as they evaluated their recall responses by scoring the accuracy of their responses, for example by adding a correct definition when they scored their response, and this was found to significantly increase the accuracy of their corrections, though they were still on average overconfident of their accuracy (Lipko et al, 2009).

As well as explicit instruction, teacher modelling of metacognitive and cognitive strategies has been found to have positive effects (Allen & Hancock, 2008). This can, for example, take the form of the teacher verbalizing their metacognitive thinking as they demonstrate a maths/writing/reading task. While demonstrating the solving of a problem, a teacher could talk through how plan, monitor and evaluate their thinking by reflecting on a series of question such as what is this problem asking, what approaches to solving it did I try and were they successful, what approach should I take to solving this problem, does my answer make sense when I reread the problem and do I need to try solving the problem with a different approach?

Implicit strategies

In addition to explicit instruction, implicit strategies such as modelling have been used to promote SRL. Using analysis from a video observation study of 20 German secondary maths school teachers and their pupils (n=538) Kister et al (2010) found that explicit but not implicit strategy instruction through modelling was associated with learning gains over time. Such explicit strategy instruction was, however, relatively infrequent in this sample. A caveat with these findings is the small sample size of teachers. Worked examples can be particularly useful in developing cognitive and metacognitive skills. Teachers can go through a problem step-by-step, demonstrating and verbalising their thought processes, and then gradually withdraw scaffolding so pupils develop more independence.

A number of interventions that have used explicit instruction have shown positive effects.

One project that used a very systematic approach was the ReflectED project, that was found to have moderate positive albeit non-significant effect size in maths, but a weak non-significant negative effect in reading among primary school pupils. In this programme pupils receive a weekly ReflectED lesson from their teacher who follows a series of lesson plans. Pupils are expected to reflect individually on their learning in other lessons and record these reflections electronically once a week. The lesson plans include tasks for the week, to support pupils to practice their metacognitive skills throughout their normal lessons. Children code their reflections to record their thoughts on a lesson and their performance. This enables them, and the teacher, to read previous reflections to inform future teaching and learning (Motteram et al, 2016).

A successful intervention with a large positive effect size in writing in late primary funded by EEF was the Improving Writing Quality project, which was trialled among year 6/7 pupils. This was based on the principle of self-regulated strategy development (SSRD) in which students are encouraged to plan, draft, edit and revise their writing by providing a clear structure to assist writers which can be used for most genres of writing. There are six basic stages of instruction and four strategies for self-regulation, which include self-monitoring and goal setting, thus providing pupils with ownership for improving their own writing (Torgerson et al, 2014). The approach makes use of key cognitive and metacognitive skills such as graphic organisers, mnemonics, self-talk, self-scoring and graphing and pre-and post-topic assessment.

An example of an approach that integrates explicit instruction in strategies with individual practice is the Self-Regulated Strategy Development (SRSD) approach. This approach, often used in reading instruction, has a number of steps:

- Develop preskills. Students' prior knowledge about the task and strategy is assessed and remediation is provided when needed.
- Discuss the strategy. The strategy to be learned is described, a purpose for using the strategy is established, and the benefits of using the strategy are presented.
- Model the strategy. The teacher cognitively models (models while thinking out loud) how to use and apply the strategy for the task.
- Memorize the strategy. Students memorize the strategy steps until they are fluent in understanding any mnemonic and meanings.
- Guided practice. Instruction is scaffolded from student–teacher collaborative practice to independence.
- Independent practice. The teacher provides independent practice across task and settings to foster generalization and maintenance.

This approach has shown positive results in a number of evaluations, albeit of variable quality and rigour (Mason, 2013; Festas et al, 2015; Mason et al, 2013).

Accuracy of judgements of learning, and of the effectiveness of particular strategies, may also require further instruction. Thus, students are often unaware of the benefits of spaced practise, and their judgements of learning can suggest that they feel massed practise is as, or more, beneficial than spaced practise, notwithstanding ample evidence to the contrary. Instruction can help alleviate this, one experimental study for example finding that that Direct Instruction on the benefits of spaced practise decreased underestimation (though it did not eliminate it), while this was not the case for simply providing feedback (Logan et al, 2012).

While there is, therefore, substantive evidence on the effectiveness of explicit instruction and modelling of cognitive and metacognitive strategies, this is not the only effective strategy, and there may be issues in transfer if only this approach is used. In a study in Dutch primary schools De Jager et al (2005) compared Direct Instruction of metacognitive skills with a Cognitive Apprenticeship approach which employed coaching, modelling, scaffolding, articulation and reflection, and a non-intervention control group in which metacognition was not explicitly addressed. The results showed that both the DI and CA approaches improved pupils' metacognition compared to the control group, but that the two approached did not differ significantly in outcomes.

Practise, dialogue and inquiry

As well as instruction, it is of course essential that SRL and metacognition are applied and practised. Here, there are a number of key differences to instruction in other areas, related to the reflective nature of metacognition, in particular, which necessitate greater use of dialogue and inquiry.

Specifically with regards to metacognitive strategies, there is a need to ensure that guided practise happens so that pupils actively employ *metacognitive reflection* on completed tasks. Typically, the more successful approaches use structured activities or templates that allow pupils to do so. One example comes from a reading comprehension intervention among middle school students which required pupils to reflect on the day's reading activity by focussing on one trained cognitive strategy, such as summarising or making connections, by making a judgement of learning on the use of the strategy, answering a set of comprehension questions focused on the cognitive strategies and memory processes (ST recollection, LT retrieval fluency, and processing speed), rechecking the text read to test accuracy and update their judgement of learning, and then receive teacher feedback (Allen & Hancock, 2008). The intervention, though limited in scope to 16 classes in one school, was successful with the treatment group outperforming both an alternative treatment group and a no-change control group.

According to Adey et al (2002) in their development of CASE, metacognitive reflection needs to follow the task, and not occur concurrently, as task completion needs to fully engage cognition. This receives support from an experimental study in Israel, in which providing metacognitive instruction after reading a scientific text was more effective than doing so either before or during reading the text among 4th graders (Michalsky et al, 2009).

As an important element of metacognition is to develop more conscious awareness of thinking around learning, dialogue and discussion can have an important role to play. This view is also based on the importance of the social element of metacognition and interaction to the development of learning.

One example of an intervention that has developed this is dialogic teaching. Dialogic teaching emphasises dialogue through which pupils learn to reason, discuss, argue and explain, and was recently enacted in an intervention in year 5 of primary school in 38 schools in England and evaluated (a control group of 38 schools was used as comparison sample). The key element of the dialogic approach is to encourage both greater quantity and quality of teacher talk, by going beyond the closed teacher question – pupil response - teacher feedback sequence. In particular, the principle behind dialogic teaching is *cumulation,* wherein teachers listen to and follow-up on what pupils have said, and use questions to elicit further thought, thus creating chains of ideas into coherent and cumulative lines of thinking (Alexander, 2015). Teachers need to be trained to develop such lines of questioning, as dialogue needs to be purposeful and not just conversation. In a recent trial funded by EEF the approach showed a significant moderate positive effect in English and science (effect sizes around .12-.15) and a weak and non-significant positive effect in maths. The fact that the intervention was only assessed over two terms may have limited effects found.

Another set of interventions that rely quite heavily on dialogue are the Let's Think secondary Science which is based on the CASE approach, and Thinking, Doing, Talking Science (TDTS), which is a primary approach tested in year 5. In the Let's Think… intervention, teachers start by providing pupils with a hook and materials, then pupils work together on solving increasingly complex problems with the teacher acting as facilitator. Towards the end of the session the teacher encourages them to reflect on their learning and to broaden their focus from the lesson specifics to other contexts (Hanley et al, 2016). The primary intervention aimed to develop teachers' questioning skills, but also to include discussion slots in their lessons aimed at discussing big questions. The approach also emphasised practical work and experiments. In the EEF evaluations, the secondary intervention was not found to have an impact in and showed poor levels of implementation in many schools, but the primary intervention showed modest positive effects, especially for pupils eligible for Free School meals (Hanley et al, 2015; Hanley et el, 2016). An approach that aimed both to develop teachers use of metacognitive strategies through a one-day workshop, and to promote metacognitive thinking in child-parent interaction through a series of animation workshops in which both were involved, the 'Mind the Gap' project, showed no significant impact on pupil outcomes, though a large reason for this may be the fact that many parents did not fully participate or dropped out of the workshop programme (Dorsett et al, 2014). Reciprocal teaching of reading strategies was found to be effective in one study of German primary school pupils, though effectiveness increased if it was combined with explicit instruction in self-regulated learning, especially with regards to longer term retention (Schunemann et al, 2013).

One aspect of dialogue that is highlighted in some successful programmes, such as Cognitive Acceleration in Science Education (CASE) is cognitive conflict, which happens when a pupil comes across a problem that cannot be solved with existing cognitive structures or processes (Adey et al, 2002). This can be developed through the use of novel and difficult problems and questions, but does require significant scaffolding from teachers. This is related to the idea of working in a pupil's 'Zone of Proximal Development', defined as the difference between what a child can do unaided and what s/he can do with the help of an adult or more informed peer.

Inquiry can also play an important role in developing self-regulation and metacognition, provided tasks are sufficiently challenging, build on firm pupil subject knowledge, are realistic, and are suitably guided and supported by the teacher. In science, for example, once they have sufficient knowledge, students can be encouraged to develop hypotheses and test these within suitable theoretical frameworks using appropriately scientific methods. This is to be distinguished from simple inquiry, where students merely observe and describe, which is often the case if their subject knowledge is not yet sufficient in the area studied (Schaw et al, 2006). Even as late as early adolescence students have been found to lack cognitive and metacognitive skills to effectively engage in inquiry learning, and in these cases it is necessary to first develop these skills, or to provide suitable guidance as demonstrated in Lazonder & Harmsen's (2016) meta-analysis on inquiry learning. In one study intended to address deficits in causal understanding detrimental to inquiry learning, students in 6th grade who received explicit instruction in making predictions based on multiple factors were able to more effectively predict and develop understanding of the relationship between variables in a system, and also did better on a transfer task than the control group (Keselman, 2003).

Scaffolding, through teacher prompting and visuals for example, are important in the individual and group practice and inquiry phases (Pratt & Urbanowski, 2016). There is some evidence that, at least in terms of metacognition, such scaffolding should not be too specific as this may inhibit reflection. In a study of middle school students in the US, Davis (2003) found that students provided with generic prompts asking them to reflect and think developed more understanding and were more productive reflectively than those provided with hints indicating potentially productive directions for their reflection. This may in part reflect the somewhat older age group of the pupils in this study, who may therefore have been able to build on substantial knowledge and developed self-regulation skills. Using so-called 'metacognitive prompts', to encourage students to engage in monitoring and reflection on the task performance, can be a useful strategy to support students during task completion (Peters & Kitsantas, 2010).

An interesting, albeit small scale experimental study among student teachers and 8th graders compared use of an open problem as proposed by inventing and productive failure approaches to use of a worked example problem. Results showed that across the two groups transfer was better supported by a worked solution, though the open problem increased interest in the trainee teacher group (Glogger-Frey et al, 2015).

An important issue is to ensure that metacognitive and SRL instruction should take a suitable step-wise approach and not overburden the learner. An interesting example of the potential issues here comes from a study of an intervention in science education among 128 German 8th graders. In this intervention the aim was to develop both students' data interpretation and self-regulation skills. Results, however, showed that students who received either only instructional support for data interpretation or only for self-regulation achieved better learning outcomes while a combination of instructional support for data interpretation and self-regulation seemed detrimental for knowledge acquisition. The students who received the combined intervention also showed the highest level of cognitive load, suggesting a potential reason for the ineffectiveness of the combined intervention compared to the individual ones (Eckhardt et al, 2013).

There is therefore clear evidence that while creating a learning environment conducive to dialogue and transfer through inquiry can help develop self-regulated learning and discussion, this in itself will not be effective, in that unguided forms of instruction have been found to lead to poorer learning outcomes than guided instruction (Harris et al, 2008; Kirschner et al, 2006).

Summary

The evidence suggests that a mix of approaches is necessary to effectively develop SRL and metacognitive knowledge and skills. Explicit teaching of strategies and teacher modelling, not least through verbalising while problem solving are an essential element of effective teaching in this area. However, in order to develop metacognitive reflection, it is also necessary to develop practise through dialogue and more open-ended, albeit guided, inquiry work in which pupils are given more autonomy over tasks within a framework of scaffolds, prompts and teacher guidance. The extent to which such inquiry activities require teacher guidance will itself depend both of the prior subject knowledge of the pupils and their self-regulatory and metacognitive skills.

Strength of evidence. The review was able to draw on a large number of studies for this overview, reflecting the depth of work in this area. While these were of very differential quality, the amount of evidence meant that the reviewers were able to focus on those studies classified as presenting at least *extensive* evidence. An issue found in a number of meta-analyses is that the effect of interventions appears larger if they are conducted by the researchers than if they are conducted by the teacher (Dignath & Butner, 2008; de Boer et al, 2014; Chiu, 1998).

In terms of directness the studies reviewed here come from a range of contexts, including the UK, and address a range of age groups. The extent of research in this area means a breadth of topics with SRL and metacognition are addressed. We can therefore provide a high (3) rating for directness, albeit with the caveat mentioned above.

8. Other key issues in teaching SRL and metacognition

While the overview above presents what we believe to be the key elements in teaching SRL and metacognition, there are a number of further debates in the field, around areas such as the extent to which teaching needs to be integrated with subject knowledge, use of group work and ICT, transfer across subjects and time, and necessary duration of interventions. These will be discussed below.

Integration with subject content

Most successful interventions are embedded with subject content, although in some cases subjects have be combined. The teaching of metacognitive knowledge and strategies has to be concrete, and related to the actual use of the strategy. Practise is therefore essential, which leads to the suggestions that a subject-specific approach is likely to be more effective (Ben-David & Zohar, 2009). The successful interventions mentioned in section 7 all took place within specific subject contexts and in relation to specific subject teaching. In part, this is related to the importance of subject knowledge to the development of SRL and metacognition. It is, for example, a good idea to activate prior knowledge, both in subject content and cognitive and metacognitive skills prior to engaging in a task, for example through providing specific questions on the topic to be studied (Tarchi, 2015). This does not, however, mean that metacognitive skills will automatically develop through content knowledge teaching. While embedder within subject knowledge, there are as mentioned above specific strategies and heuristics which need to be developed.

The lack of integration with subject may be one of the reasons why the metacognitive intervention programme ‘Mind the Gap’ failed to achieve significant outcomes (Dorsett et al, 2014), though it is possible that the preponderance of subject-based programmes among successful interventions is related to the structure of education and the role of subject teachers rather than an inherent lack of effectiveness for a generic approach. In primary, the subject specificity is less apparent, possibly as teachers teach across subjects.

As mentioned above, some approaches have combined subjects, albeit with mixed results. The successfully tested Reading Apprenticeship model, in which reading literacy in science among secondary school pupils was targeted, combined reading literacy and science from the perspective that the complex scientific texts read require specific literacy development. This was done through the use of authentic tests such as lab reports and journal articles, explicit teaching of metacognitive strategies, modelling, practise and discussion (all of which elements we will see reappear in other successful projects) (Greenleaf et al, 2011). On the other hand, a combined intervention including data interpretation and self-regulation in German 8th grade science students also did not show positive impacts (Eckhardt et al, 2016).

An approach that has attempted to steer a midway between subject-embedded teaching and generic lessons is the Activating Children’s Thinking Skills approach, which uses professional development to get teachers to explicitly teach thinking skills across the curriculum (McGuinness, 2005). The approach hasn’t been subject to very rigorous evaluation, however, though one quasi-experimental study showed greater gains on a cognitive ability test for an intervention group compared to the control group in Northern Ireland (Dewey & Bento, 2009).

Intervention duration

The evidence on how long an intervention to improve SRL and metacognition needs to take is somewhat unclear, which is probably a reflection of the breadth of approaches in existence which makes generalisation hard.

Meta analyses present a mixed picture. In their meta-analysis of strategy instruction de Boer et al found a slightly lower effect size for longer interventions (e.g. 20 weeks) than for shorter interventions (e.g. 10 weeks), and no effect of intensity (number of sessions per week), though longer individual sessions had a slightly stronger effect than shorter ones. Chiu (1998) did not find much impact of length of intervention on reading outcomes, though an overly condensed approach showed lower effect sizes. Likewise, in his meta-analysis of metacognitive interventions in reading comprehension, Fauzan (2011) did not find an effect of duration. Dignath and Buttner (2008), however, found that interventions are more effective the longer they are in time, which points to the developmental nature of self-regulation, where strategy use improves and can become automated over time.

Most effective interventions reviewed in this overview seemed to be of relatively long duration of at least a term and more typically a whole schools year, with at least on session per week. However, this was also true of the less effective interventions. Adey et al (2002) in developing CASE specifically used a two-year framework (years 7 and 8) to ensure a sufficiently long timescale for development and change. But there is evidence that short term training on metacognition can also lead to measurable gains on the aspects trained on, but this may be less likely to lead to actual attainment gains or transfer. An example of this is a project in which primary school children were given 5 sessions of training on metacognition and cognitive skills. They did subsequently outperform children in the control group on a test of these skills, but no generalization effects were found on transfer of cognitive learning (Desoete & Roeyers, 2003).

In summary, the evidence on duration and intensity is unclear, not least due to difficulty in systematically studying these factors.

Group work

Many interventions in this field make us of collaborative group work. However, the effect of this is not clear. Some analyses support the use of small group work, such as Chiu's (19998) meta-analysis of metacognitive interventions in reading. De Boer et al (2014) however, find in their meta-analysis of strategy instruction that interventions using cooperative learning had a lower effect size than those that didn't, while Dignath and Butttner (2008) found a slightly negative effect of group work, that did not, however, reach statistical significance.

The Let's Think Secondary Science intervention, which used group work as one of its constituent elements did not show any positive effects in the EEF funded evaluation thereof, and the group work element was not always well received by teachers who complained of misbehaviour (Hanley et al, 2016). Reciprocal teaching, where students tutor each other in small groups, taking on different roles each time, has also been suggested as a potentially useful method to create dialogue among pupils and develop thinking skills. However, an intervention (the LIT programme) designed to improve literacy skills of low performers in year seven heavily based on this approach showed no significant effects in an EEF funded trial (Crawford & Skipp, 2014). The Reading Apprenticeship approach, which showed positive impact in one evaluation in the US, made extensive use of group work as part of its approach (Greenleaf et al, 2011), and Slavin's (2013) systematic review also found positive effects of interventions using cooperative group work. Kramarski and Mevarech (2003) found that an intervention using cooperative learning and metacognitive training did significantly better than a group given individualised learning and metacognitive training in their study of Israeli 8th graders.

Collaboration scripts have been posited as one way of making collaborative group work more effective. These are used to support group work by introducing a series of activities and prompts, such as explanations, conflict resolutions, and mutual regulation, which will make the activity much more structured and could encourage metacognition (Chen & Chiu, 2016). The evidence for this approach is still somewhat limited, however, and overall there is little convincing evidence to suggest that group work is a necessary component of the development of SRL and metacognition.

ICT

Computer-based learning environments (CBLE) have been said to potentially be effective environments for the development of metacognition, through their ability to create open-ended tasks, use multimedia to explore complex topics, and ease of presentation non-linear material.

However, they have also been found to be challenging to students, who will need to possess good prior knowledge and cognitive and metacognitive skills in order to effectively work in these environments, and suitable motivation to avoid distractions. Evidence on the effectiveness of such approaches is mixed and limited to date (Devolder et al, 2012).

Where used, CBLE's are most effective if they incorporate strong scaffolds, defined as '. . . the provision of technology-mediated support to learners as they engage in a specific learning task' (Sharma & Hannafin, 2007, p. 29). These scaffolds can help make different aspects of metacognition more explicit to the learner, for example through use of prompting questions eliciting reflection on the content or learning strategies being used (Quintana et al, 2005). Such scaffolds have been categorised into four types:

- Conceptual scaffolds which guide the learner in what to consider when a problem or task is already defined;
- Metacognitive scaffolds which provide different ways to think about a problem or different strategies that need to be considered;
- Procedural scaffolds that guide learners in using the features available in open-ended learning environments; and
- Strategic scaffolds that help the learner understand how to approach tasks or problems.

Use of prompts and worked examples have been found to be useful in this regard in Devolder et al's (2012) meta-analysis, and a CBLE intervention using scaffolds to support metacognition (metacognitive support mechanisms) showed positive outcomes for 13 and 14 year olds in a quasi-experimental study in which this helped them to move from solving structured problems (near transfer) to solving open-ended problems (far transfer) (Kapa, 2007).

Web 2.0 tools provide a number of opportunities to develop learning environments that support elements of self-regulation and metacognition, in particular in the inquiry or dialogue phase of the process. Social software and user-generated micro content, along with the scaffolding tools mentioned above, provide opportunities for practise and can extend metacognitive learning beyond the classroom. These can be integrated into self-regulatory processes where the student moves from task analysis, makes choices regarding next actions, and then uses scaffolding tools to reflect on these choice (Rahimi et al, 2015). Without clear scaffolding, however, the more open online learning environments tend to be ineffective as students struggle to develop effective strategies (Segedy et al, 2014). A problem is that in many cases students do not make use of the prompts and scaffolds in online learning environments, and that use thereof diminishes over time (Roscoe et al, 2013; Taub et al, 2017). Roscoe et al (20113) suggest that one reason for this is that learners may require significant level of both SRL skills and domain specific knowledge before engaging in the open online environment. Learners may also discover ways to reach the solution that do not require the intended learning, so called 'gaming the system'. A possible solution is involvement of the teacher to encourage pupils to use scaffolds and prompts. In one study, scaffolding provided both in the online environment and by the teacher showed better outcomes than scaffolding provided by the online environment on their own, which in turn provided better outcomes than no scaffolding in both domain specific knowledge and metacognitive awareness among secondary students (Raes et al, 2012).

As well as in the development of CBLE's ICT can aid in particular activities by lightening the load for teachers. For example, collaboration scripts can be developed electronically, for example through design activities in a multi-touch environment (Chen & Chiu, 2016). In one study of Taiwanese fifth graders, computerized scripts which provided a sequence of guidance for structuring intragroup and intergroup interactions and prompting individual metacognitive processes throughout the collaborative design phases based on the Think-Pair-Share method was used in an intervention (Chen & Chiu, 2016). Similarly computerised instruction used in a second grade maths classroom which used fluency and cognitive strategy instruction showed positive effects in one quasi-experimental study in the US (Carr et al, 2011). In these interventions it is not necessarily the case that ICT is doing anything that teachers could also not do, but it may lighten teacher workload and extend the possible use of these instructional strategies to contexts in which trained teachers are not available.

Assessment

An element of instruction that has been found to be related to the development of metacognition and SRL is assessment, and in particular formative assessment and feedback strategies often know as Assessment for Learning (AfL). Such strategies provide students with a means to monitor progress as well as scaffolding for the revision of strategies used. One Dutch study in primary education, for example, found a positive relationship between pupils self-reported exposure to AfL and use of metacognitive strategies (Baas et al, 2015).

A key skill in terms of monitoring is the development of accurate judgements of learning among students. Studies show that pupils, especially at younger ages (but certainly into early adolescence), tend to overestimate the accuracy of their judgements and the extent of their learning, and that more accurate judgements of learning are associated with higher attainment (Garcia et al, 2016). Addressing *calibration* is therefore important, and points to the need for feedback to be accurate and point to lack of success where necessary rather than focusing on self-esteem building.

More generally, testing can aid self-regulation and metacognition. Retrieval practice, where pupils deliberately recall information, can help to aid transfer and organize information, and along with teacher quizzes can lead to more accurate judgement of learning (Roediger et al, 2011).

Transfer

Transfer, defined in most studies as the extent to which strategies and skills acquired in one context can effectively be employed by the learner in different contexts (Seel, 2012), would appear to be a key question in SRL and metacognition. Nevertheless, few studies have looked at transfer across subjects, most being limited to a particular subject domain. Some exceptions to this suggest there is some transfer across subjects. The CASE evaluations, for example, have shown the intervention to lead to enhanced performance at GCSE not just in science but in a range of subjects (Adey & Shayer, 1994), while one intervention that integrated literacy and science in a professional development programme for teachers saw improvements in student outcomes in both literacy and science among high school students compared to a control group (Greenleaf et al, 2011). This intervention was designed to ensure that students can access scientific content, which is different from everyday literacy, and integrated a focus on metacognition.

Declarative metacognition or metacognitive knowledge has been found to become more generic over time. The development of metacognitive knowledge begins with very domain specific knowledge of particular strategies and approaches suited to a particular area. Relational knowledge then develops more slowly, but eventually leads to the development of more flexible and interconnected strategy knowledge, which will result in the possession of a range of more or less general strategies which can be applied across contexts (Siegler, 2007; Neuenhaus et al, 2011). As a specific strategy is used and practised, learners will get to know its strengths and weaknesses better and start to understand the extent to which it can be applied to novel contexts. Neuenhaus et al (2011) studied the development of metacognition among German fifth graders, and found both a degree of domain specificity, but also already the development of more general metacognitive knowledge as MK in reading and maths showed moderate correlations with one another and with a measure of general metacognitive knowledge, suggesting that at this stage pupils are already starting to transfer domain specific strategy use to broader situations. Domain specific MK was more strongly correlated with attainment in the respective subjects than general MK, though correlations were still only moderate.

Metacognitive monitoring likewise could be either domain specific, which would mean that e.g. judgements of learning would be more accurate when applied in a domain in which the learner has significant prior knowledge than in others, or general, in which case learners would be able to make reasonably accurate judgements even in domains where they do not have strong knowledge (Gutierrez et al, 2016). As with metacognitive knowledge, metacognitive monitoring appears to develop from the domain specific to the general over time, as learners start to develop a repertoire of monitoring skills they can apply even to less known domains, such as goal setting and self-testing, with pupils by middle school showing both domain specific and general competencies, but moving more towards the latter over the course of their education (van der Stel & Veenman, 2010), while a study of undergraduates suggested that a more general model was by then dominant (Gutierrez et al, 2016). In an admittedly small-scale study Veenman and Spaans (2005) found that correlations between metacognitive skills in different domains were a lot stronger among 15 years olds than among 12-year olds.

All this may suggest that the trajectory we see in some interventions, which is that primary interventions are often more generic while secondary interventions tend to be subject-based may in fact not reflect what is currently known about the development of metacognitive knowledge and skills so much as it is linked to the typical structure and roles of teachers in primary and secondary education. There is also some evidence pointing to the importance of guided practice as well as instruction to the enabling of transfer, with one study, for example, finding that students given guided practice showed greater transfer of metacognitive strategies to reading comprehension than those given only direct instruction on the strategies (Lenhardt et al, 2013).

Longitudinal studies suggest that learning is retained over time to a moderate to strong extent, in particular, where explicit teaching and practice through inquiry are combined (e.g. Ben-David & Zohar, 2009)

Strength of evidence. Strength of evidence for these areas tends to be lower than for the effective strategies reviewed in section 8. The evidence for intervention duration and group work is inconclusive, and that for content integration also far from clear-cut. For ICT we had to go down to moderate levels of evidence strength, and for transfer we had to include some studies with limited strength.

In terms of directness, the limited number of studies in some areas, such as transfer, mean that age groups and contexts are also limited in number.

9. Differential effectiveness by subject, age and domain

Differences by age/grade

As has been highlighted earlier on in this review, SRL and metacognition develop over the period of formal education, and weaknesses in metacognitive skills and strategies are found among older adolescents as well as among young children, so there is no age group for which metacognitive interventions are likely to be without use. This does raise the question of the extent to which different teaching strategies or intervention approaches may be appropriate for different age groups.

While there are examples of effective interventions for all age groups, there do appear to be some differences in effects. Chiu (1998)'s meta-analysis of metacognitive interventions in reading found higher effect sizes if the intervention took place in grade 5 or higher. The explanation given by Chiu was that this is linked to the slow development of metacognitive skills, but recent research does not necessarily corroborate that, painting a more subtle picture of early metacognitive development. Dignath & Buttner (2008), on the contrary, found the mean effects of interventions in SRL to be similar in primary and secondary education, which was also the case for Perry et al (2012), while Fauzan (2011) found effects in early primary school to be as high as they were in college, with lower effect sizes in grades 10-11 in his meta-analysis on metacognitive interventions reading comprehension. In the UK, EEF-evaluated interventions focusing at least in part on metacognition have more often been successful in primary than in secondary education. It is possible to develop interventions that improve self-regulated learning in early years setting. For example, in one German intervention, training Kindergarten teachers (n=35, a small sample then) in SRL led to improvements in both their own and their pupils use of self-regulation (Perels et al, 2009). Overall, there does not appear to be compelling evidence that effects of interventions differ majorly by age group or school phase.

In terms of approaches, primary interventions are more often generic, especially at Key Stage 1, while secondary interventions that have shown positive effects are pretty much all delivered through subjects (e.g. Adey et al, 2002; Motteram et al, 2016). This, especially for the younger age children, needs to be tempered however by the fact that cognitive and metacognitive strategies are task-dependent and acquired around concrete learning situations first, and are only later generalized through the development of more relational knowledge (Neuenhaus et al, 2011). This implies that early development of metacognitive knowledge in particular is best done through connection to specific subject-based learning activities at younger as well as at later ages.

The younger the child, the more explicit instruction is typically needed, as unguided instruction is likely to run up against limitations of knowledge and skills (Shaw et al, 2006). There is also some suggestion in the evidence that collaborative approaches may work better in secondary than in primary, with the most effective interventions using collaborative approaches taking place in secondary (Kramarski & Mevarech, 2003; Greenleaf et al, 2011) possibly due to the greater maturity of this age group.

Adey et al (2002) suggest that at earlier stages a shorter (one year) intervention is appropriate, while at secondary two years are necessary.

Differences by subject and domain

The main evidence in the field relates to the subjects of mathematics, science and literacy, as the majority of interventions and studies have taken place in these subjects, with some studies in the areas of English Language Learning ELL and a limited number on other subjects. Generally speaking, intervention effects have been found in all subjects, though with some differences in strength, with Donker et al (2014) finding higher effect sizes in writing, and lower effect sizes in reading, with maths and science in an intermediate (moderate) position). Higgins et al (2005) found effects of thinking skills interventions to be somewhat higher in maths and science than in reading in their evidence synthesis, and Perry et al (2012) report no significant differences between maths, reading and writing in their meta-analysis. Dignath and Buttner (2008) found that effect sizes were higher in mathematics than in other subjects. One study among first year undergraduates found no differences in the structure of SRL between subject domains. Course specific measures of SRL were also no more accurate in predicting academic achievements than the general version (Rotgans & Schmidt, 2009).

A key finding is that domain and subject matter, as discussed earlier in the report, metacognition and SRL are context-dependent to a large extent, and draw on strong domain and subject knowledge, which means that a. subject knowledge is important to the development of strong metacognitive skills, and b. such skills will not necessarily transfer from one subject or domain to another. In other words, it is not a generic set of transferable skills. However, while there is widespread acknowledgement in the literature that such domain differences exist (for example, textual analysis in history requires different forms of monitoring and control than the understanding of graphs in maths and science), there is little research that has systematically studied what the key differences between subjects are, and the actual pedagogical practices reported tend to show similarities across subjects (Poitras & Lajoie, 2013).

In *literacy* Chiu (1998) found small group interventions to be particularly effective, and more so that either large group or one-to-one interventions in their meta-analysis, though the reciprocal teaching approach used in the LIT programme was not found to be particularly effective (Crawford & Skill, 2014). Successful text comprehension has been found to involve metacognition, in part through the usual metacognitive process of monitoring and awareness of own strengths and weaknesses, but also through necessary mediation between text, reader and context that allows understanding to develop. This also requires explicit instruction in comprehension strategies through explanation, modelling and guided practise (Allen & Hancock, 2008). Similarly, in writing there is evidence that teaching writing strategies along with self-regulation strategies is more effective than teaching writing strategies on their own (Brunstein & Glaser, 2011), with one meta-analysis showing that adding self-regulation to strategy instruction had a moderate to strong effect size on writing assessments (Graham et al, 2012). In early literacy, there is some evidence that the systematic teaching of phonics and phonemic awareness can usefully be enhanced by the teaching of metacognitive strategies. The 'Think About It' programme, trialled in North Lanarkshire, Scotland, successfully did exactly that, though it was not possible in the evaluation to determining which elements of the programme had added to the effect (Ferguson et al, 2011).

In *mathematics* there has been a lot of attention paid to problem solving, and the role of modelling when engaging in problem solving activities. For pupils to be effective problem solvers, they need sufficient knowledge and problem-solving skills, which can be taught and developed as part of self-regulation. In many cases, the use of specific problem-solving strategies and algorithms can be useful to help develop these skills (Shraw et al, 2006; De Corte et al, 1996). Children do not necessarily know solving strategies and don't necessarily develop these spontaneously, and explicit teaching of heuristics can therefore be helpful. For example, in the SOLVED intervention third graders taught a sequence for word problem solving (problem translation, problem interpretation, solution planning, solution execution, and solution monitoring) significantly outperformed a matched comparison group given traditional word problem instruction among primary school pupils (Hohn & Frey, 2002). Modest positive effects were also found for an explicit problem-solving approach in secondary, schema-based instruction (SBI), which emphasizes the underlying mathematical structure of problems, uses schematic diagrams to represent information in the problem text, provides explicit problem-solving and metacognitive strategy instruction, and focuses on the flexible use of multiple solution strategies (Jitendra et al, 2015). In addition, spatial skills such as mental rotation skills may require specific development (Bokhove & Redhead, 2016).

A specific issue that reoccurs in the literature is that of *maths anxiety,* a feeling of lack of competence and fear of the subject that seems more prevalent here than in most other curriculum areas. Here there is some limited evidence that interventions focused on improving self-regulation and metacognition can reduce anxiety (for example Kramarski et al, 2010, among Israeli 3rd graders), though it is likely that experiencing success at maths will also be an important factor in alleviating this problem as causality is likely to be bi-directional.

In *science* there has been a long tradition of work in the area of SRL, particularly through the Cognitive Acceleration in Science Education (CASE) programme, first started in the 1980's, and its successors. This programme was based on the notion that cognition can be developed through a series of science lessons (30 in the original programme) that incorporated cognitive conflict, social construction, metacognitive development and schema theory (see above). This programme has shown significant positive impacts in a series of evaluations, mostly conducted by the programme developers (Adey ate al, 2002; Muijs & Reynolds, 2010). The Let's think Secondary Science evaluation that was based on the CASE approach and was externally evaluated did not show a positive effect, but the programme did adapt a number of elements of CASE, such as reducing the number of sessions from 30 to 19 and changing some of the science content (Hanley et al, 2016). The primary Thinking Doing Talking Science intervention did show (moderately) positive effects. A specific element of a lot of successful science interventions is an emphasis on practical work, in particular the carrying out of experiments (e.g. Hanley et al, 2015). A key element in science approaches is the use of scientific thinking, which is encouraged through hands-on inquiries and experiments, albeit that these need to be sufficiently demanding and theoretically sound (see above and Scha et al, 2006). Students have difficulty learning the nature of science through implicit means because it is difficult to understand the nature of science through inquiry alone (Peeters & Kitsantsas, 2010).

Some specific models exist for other subjects such as history (Poitras & Lajoie, 2013), Physical Education (Kolovelonis & Goudas, 2013; Huijghen et al, 2015), Religious Education (Larkin et al, 2014) and Foreign Language Learning (Cotterall & Murray, 2009).

Strength of evidence. Strength of evidence for differential effects was relatively limited, and we had to use evidence of moderate strength in this area, as well as inference from studies of individual subjects and age groups.

The majority of studies reviewed here were conducted outside of the UK, though they address a range of age groups and it is likely that the findings will be applicable as subject structures are relatively similar across these contexts, making the findings moderately direct (2).

10. Implementation of metacognitive interventions

Where SRL and metacognition requires changing practise, as in the case of the interventions reviewed above, the question of implementation comes to the fore, not least as it is likely that at least some of the differential effects of interventions evaluated by EEF are due to implementation issues rather than to the content of the intervention in itself. Therefore, it is important to take into account what studies can tell us with regards to effective implementation.

One aspect that is clear that if changes in practice are to occur, sufficient time needs to be given for these to happen, For example, in the overall successful Dialogic Teaching intervention mentioned above, a weakness expressed by teachers was that the two terms of the intervention represented too short a timeframe to fully embed the approach and see its effects (Jay et al, 2017).

Extensive support for teachers is important, and it is key to provide sufficient time for implementation and assimilation into teaching of any new approaches (Anders et al, EEF). Extensive professional development for teachers was found to be key in Slavin’s (2013) systematic review of interventions in mathematics and reading. In the Dialogic Teaching intervention teachers received training, ongoing monitoring and support from the development team, a pack containing study and reference materials, and a development and mentoring manual (Jay et al, 2017). The core training included mentoring, video and audio recording for self-evaluation and development and an iterative process of target-setting, implementation, recording, and review. Schools thus received a range of materials and support, with a mentor appointed in each school to support year 5 teachers. 11 training sessions were delivered over the course of the intervention. Another intervention which was partially successful, ReflectED, also provided quite extensive support for teachers. At the beginning of the year, participating teachers received a pack of lesson plans and supporting resources, and an initial day-long training session. This was followed by three additional half-day training sessions throughout the year. A website, digital resources, and weekly reminders and tips were provided by the London Connected Learning Centre Motteram et al, 2016). Teachers in the ReflectED programme liked its systematic approach but suggested it would work best as a whole-school programme. The Let's Think Secondary Science programme, on the other hand, saw poor implementation (Hanley et al, 2017), with many teachers modifying the approach and complaints about aspects of training and support. The Mind the Gap programme, which showed no significant effect, used a one-day training workshop for teachers which may have been inadequate in terms of time. However, while extent of support and development matters, too great an intensity leads to greater attrition from intervention programmes, so a balance will need to be struck between providing sufficient training and support and not overly increasing the burden on schools and teachers (Anders et al, EEF).

Support from senior leadership and provision of time for teachers were found to be important to implementation in the Dialogic Teaching intervention, and have been found to be key in many studies of educational change. Mentoring was also seen as successful. Conversely, lack of time, over complexity and conflicting school priorities were key barriers to implementation (Jay et al, 2017, Anders et al, EEF). Materials and timing need to fit in the school year, and interventions ultimately need to be delivered through relevant subject lessons. Programmes where pupils are withdrawn from class are less effective and tend to encounter resistance, as are those that require parental involvement or out of hours pupil attendance (Anders et al).

Most interventions by definition involve teacher development, and it is therefore important that the key principles of effective professional development are followed. Teacher professional development needs to be built on and into subject content and often develop both content knowledge and pedagogical content knowledge, be curriculum-aligned, be of substantial duration, and actively involve the teachers in learning and reflection (Desimone, 2009; Muijs et al, 2014; Cohen & Hill, 2001). In their overview of research on effective CPD for the Teacher Development Trust, Cordingley et al (2015) identified the following key aspects of effective CPD:

- Sufficient time needs to be devoted to CPD, preferably at least two terms
- Activities need to be iterative and build on how well approaches are working in the classroom
- CPD needs to build on teachers starting points, and explore but where necessarily challenge existing beliefs and practices
- CPD needs to focus firmly on pupil learning
- Internal input is helpful as it can challenge existing beliefs more easily
- External and internal facilitators need both subject expertise and expertise on CPD delivery
- Peer support is useful to encourage reflection and risk taking
- Metacognition and SRL are important parts of CPD (!)

Working directly with teachers has been found to be effective as a strategy in terms of embedding metacognition into teaching and therefore learning. In one intervention, Askell-Williams et al (2012) collaborated with teachers to embed explicit cognitive and metacognitive strategy instruction using learning protocols, into regular class lessons. Results showed that the teachers did indeed use the learning protocols in typical lessons.

Interventions are likely to be more successful if they take place in schools that are receptive to the type of intervention proposed. As such, school climate and ethos matter, in that in schools where there is greater willingness and capacity to innovate, and where there is a positive disposition towards the principle of SRL there is likely to be a more positive intervention effect.

One intervention to develop SRL in vocational schools in the Netherlands, for example, was not successful in many schools due to the fact that teachers reacted negatively to the top-down reform and did not wish to change existing practices. Insufficient support and guidance for teachers were identified as a key part of the problem (Jossberger et al, 2015). A successful intervention in Hong Kong showed the opposite, with teacher support for SRL key to effective implementation (Lau, 2013). Teachers self-efficacy was found to influence their use of self-regulation among Greek mathematics teachers (Chatzistamatiou et al, 2014), which may suggest that teachers own subject knowledge and pedagogical knowledge may be important, as these can directly affect self-efficacy beliefs. There is some evidence that teachers own metacognitive knowledge is related to that of their pupils (e.g. Soodla et al, 2017).

There is evidence from studies in Israel that incorporating SRL in teachers own professional development can enhance the effectiveness of CPD programmes (Karmarski & Revach, 2009; Kramarski & Michalski, 2009).

While many of these strategies are general to implementation rather than specific to SRL and metacognition, there are some specific issues in implementing metacognitive interventions. Firstly, there is a distinct lack of understanding of the term metacognition among many teachers, which in turn leads to misconceptions and often weak implementation. Therefore, it is important to first address teacher knowledge and understanding of key concepts, and to ensure that the full range of instructional strategies mentioned above are known to them (Dignath & Buttner, 2017, De Smul et al, 2017).

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