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Using Load Reduction Instruction (LRI) to boost motivation and engagement

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Further information

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Executive Summary

The escalation in academic demands through school underscores the need to approach instruction in ways that appropriately manages the burden on learners where possible and feasible.

Cognitive psychology has been informative in identifying instructional approaches that are directly aimed at managing the cognitive load on students to better help them learn and achieve.

Load reduction instruction (LRI) is an umbrella term referring to instructional approaches that seek to reduce and/or manage cognitive load in order to optimize students' learning and achievement.

LRI encompasses explicit and direct instruction. At the appropriate point in learning, LRI also involves less structured approaches such as guided discovery-, problem-, and inquiry-based learning.

A major tenet of LRI is that students are at first novices with respect to academic skill and subject matter and that a structured and somewhat directional approach to instruction that reduces cognitive load is important for learning and achievement in the early stages of learning.

Then, as core skill, knowledge, fluency and automaticity develop, LRI emphasizes the centrality of guided discovery-, problem-, and inquiry-based learning.

LRI is based on five principles at key points in the learning process:

(1) Reducing the difficulty of a task during initial learning;

(2) Instructional support and scaffolding through the task;

(3) Ample structured practice;

(4) Appropriate provision of instructional feedback; and

(5) Independent practice, supported autonomy, and guided discovery learning.

Although numerous frameworks have recognized the roles of explicit or discovery approaches, LRI is distinct in that its emphasis is on reducing or managing the cognitive burden on students as they learn and that this can comprise both explicit and discovery approaches.

LRI is thus termed, framed, and developed deliberately to indicate *why* we engage its various instructional elements - namely, to deliver instruction and instructional support so as to appropriately reduce or manage the cognitive burden on the learner.

Essentially, LRI helps build the content of long-term memory and develops a level of fluency and automaticity that frees up working memory to apply to a given task or problem.

Importantly, fluency and automaticity also have implications for students' motivation and engagement.

However, relatively little attention has been given to the role of LRI in students' academic motivation and engagement. The present review thus considers the relationship between motivation, engagement, and LRI.

The Motivation and Engagement Wheel is the framework used to explore LRI and its motivation and engagement links. The Motivation and Engagement Wheel comprises four overarching dimensions of motivation and engagement, each comprising specific motivation and engagement factors:

- Positive Motivation: self-efficacy, valuing, mastery orientation;

- Positive Engagement: planning and monitoring behavior, task management, persistence;
- Negative Motivation: anxiety, failure avoidance (fear of failure), uncertain (low) control;
- Negative Engagement: self-handicapping, disengagement.

The review examines each of these motivation and engagement factors and explores the extent to which specific approaches and strategies under LRI can address them. In so doing, the review complements the large body of work into LRI and its achievement effects with closer consideration of its potential yields for students' motivation and engagement.

In addressing these issues, the review is organized into five parts.

Part 1. Load Reduction Instruction: (i) definition and description of LRI, (ii) a review of human cognitive architecture as relevant to LRI, (iii) consideration of fluency and automaticity, (iv) a summary of LRI effects on achievement, (v) consideration of LRI for diverse learners and subject areas, and (vi) identification of specific load reduction instructional elements.

Part 2. Motivation and Engagement: (vii) definition and description of motivation and engagement and (viii) a motivation and engagement framework for considering LRI.

Part 3. Load Reduction Instruction, Motivation, and Engagement: (ix) LRI approaches for specific motivation and engagement dimensions.

Part 4. Load Reduction Instruction and the Broader Process of Learning: (x) the role of guided discovery learning and (xi) understanding the optimal learning sequence.

Part 5. Looking Forward: (xii) Opportunities for future research in LRI, explicit instruction, motivation, and engagement.

Taken together, it is important to recognize the motivating and engaging properties of clear, structured and well guided instruction, and the implications this has for students' learning and achievement outcomes. Load Reduction Instruction (LRI) is proposed herein as an effective pedagogical means of supporting students' motivation, engagement, learning, and achievement at school - and beyond.

Foreword

Hazel Francis

THE VERNON-WALL LECTURES have been highlights of the annual conferences of the Psychology of Education Section of the British Psychological Society (BPS) for more than 30 years. The current Section committee believes that in future the membership would welcome a foreword to each published lecture with information about the origin of the series and the lives of the two men it honours. I am happy to have been invited to help since I was personally involved in establishing the series, both men were known personally to me, and both preceded me in the University of London Chair in Educational Psychology, held at the Institute of Education.

To account for the origin I go back to 1980 when the Section was simply named the Education Section of the BPS. As its committee chair I was present at a BPS Council meeting when it was reported that the BPS held royalties from publications by Philip Vernon and William Wall and was seeking advice on how best to deploy the funds. Given the nature of their contributions to psychology, and the regard in which they were held, I suggested the Education Section be consulted, with the result that Council agreed to fund an annual lecture to be named after the two men and to be given at the Section annual conference and thereafter published. But what, may be asked, was the nature of the work being appreciated in this recognition? It was certainly not the same for both.

When Philip Vernon began his degree studies at Cambridge in 1927 he was already acquainted with psychology (his father was a well-known industrial psychologist) and was interested in work on mental development. His Master's and doctoral studies there set him on a life course as a noted research figure in the fields of human personality, skill and intelligence. His work on personality and its measurement was influenced from the start by the then ongoing work of Gordon Allport in America, whilst that on intelligence developed in relation to that of Cyril Burt and Charles Spearman in London, work which focused on attempts to measure human intelligence and skills and to explore their structure through statistical analysis (notably factor analysis) of such data. By 1938 Vernon had held a variety of academic positions on both sides of the Atlantic before being appointed to the Chair in Psychology at Glasgow University, a position he held until 1947 and from which he advised the Admiralty and the War Office on the training and selection of recruits during World War Two. In 1949 he was appointed to the Chair in Educational Psychology at London, a position from which he published major works on the nature and assessment of personality and intelligence. There can hardly have been a psychology graduate in the country who did not know of his work and appreciate the distinction he made between theoretical intelligence (ability influenced by heredity and environment) and measured intelligence as descriptive of tested performance on various criteria. Having established an international reputation in the field of educational psychology he retired from London in 1968 to a Chair in Educational Psychology in Calgary where he continued to work and publish until 1978. In 1979 he published a major work entitled *Intelligence – Heredity and Environment* drawing together major issues in the highly controversial field to which he had made such an outstanding contribution.

In addition to his university appointments Philip Vernon was active in the work of the BPS. He edited the *British Journal of Educational Psychology* and was welcomed at conferences where his presence was much appreciated, not least for his quiet openness and friendly helpfulness. I last heard from him in 1985 when we enjoyed an exchange of letters and he made very apt comments on the problems of measurement of complex educational skills.

William Wall, generally known as Bill, pursued educational problems of a different sort. Like Vernon he was born before World War One and began his career in the depression years of the 1930s, but (ever an impressive amateur artist) he first trained as an architect. Lack of employment prospects led him to take a degree in English and to become a secondary school teacher. World War Two service brought him into contact with illiterate recruits whose plight so moved him that he felt committed to working to improve educational provision for adolescents. To arm himself for this cause he pursued a psychology degree at University College, London, followed by a doctorate from the University of Birmingham where he had taken a teaching post. After a brief period on the staff of the university his particular motivation and his excellent French took him to a post in Paris with UNESCO to work on child development and education.

Here he met the desperate need for educational development in the post-war world. He made numerous international contacts and advised on projects in several countries including the UK, where the BPS involved him in assisting local authorities to develop educational psychology services. In 1956 his appreciation of the need for psychological research in educational development lay behind his appointment to the post of Director of the National Foundation for Educational Research where he facilitated a number of projects including the National Child Development Study. The international interest prevailed, however, and in 1968 he moved to the London University Institute of Education where, as Dean, he was able to work with staff involved in international development and in the education and training of staff and students from overseas centres. He maintained such work, particularly with reference to adolescent development and education, when he was appointed to the Chair in Educational Psychology in 1972 and later, from 1978, when he retired to work for the Bernard van Leer Foundation.

I came to know Bill personally when I moved to the London Chair. He was helpful and kind and, true to character, he had me working on a publication for van Leer and UNESCO before I had laid the foundations in London for continuing my own work. Bill was not so much a research psychologist himself as a man with a mission to use research to encourage and develop services, particularly for educationally needy adolescents.

As might be imagined, the extensive publications of the two men reflect their different, but hugely important, contributions to psychology and education. I believe the Section made a very good decision to honour the value of psychological enquiry in the context of educational needs when it drew these two men together in establishing the Vernon-Wall Lectures.

Hazel Francis
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Can educators reduce students' cognitive load and boost motivation and engagement?

Integrating explicit instruction and discovery learning through Load Reduction Instruction (LRI)

Andrew J. Martin

Load Reduction Instruction (LRI) is an umbrella term referring to instructional approaches that seek to reduce cognitive load in order to optimise students' learning and achievement. LRI typically encompasses explicit and direct instruction, and under particular conditions can also encompass less structured approaches such as guided discovery-, problem-, and inquiry-based learning. Theory and research support the role of LRI in students' academic learning and achievement. Relatively less attention has been given to the role of LRI in students' academic motivation and engagement. This review examines key dimensions of motivation and engagement and explores the extent to which specific approaches and strategies under LRI may promote them. A major tenet of the review is that students are at first novices with respect to academic skill and subject matter and that a structured and somewhat directional approach to instruction that reduces cognitive load is important for achievement, motivation, and engagement in the early stages of learning. LRI helps build the content of long-term memory and develops a level of fluency and automaticity that frees up working memory to apply to a given task or problem. As discussed, this fluency and automaticity has implications for students' motivation and engagement. Importantly, as core skill, knowledge and automaticity further develop, LRI emphasises the centrality of guided discovery-, problem-, and inquiry-based learning. Introduced at the appropriate point in the learning process, these scaffolded exploratory approaches can also be a means to manage cognitive load, generate autonomous learning, and provide a further basis for students' motivation and engagement. The review concludes by showing how these instructional practices that unambiguously emphasise the role of the teacher are in fact predominantly student-centered and student-salient. Taken together, it is considered important to recognise the motivating and engaging properties of clear, structured and well guided instruction, and the implications this has for students' learning and achievement outcomes.

INTRODUCTION

School is academically demanding and becomes more so as students move from elementary school to middle school to high school. Across these stages of schooling (and year levels within them), there is an escalation in homework, frequency and difficulty of assessment, content to be covered, subject difficulty, and competing deadlines (Anderman, 2013; Anderman & Mueller, 2010; Graham & Hill, 2003; Hanewald, 2013; Kvaslund, 2000; Martin, 2015; Martin, Way, Bobis & Anderson, 2015; Zeedyk, Gallacher, Henderson, Hope, Husband & Lindsay, 2003). This progressive escalation in challenge places increased cognitive demands on students.

At the same time, there are well-documented declines in motivation and engagement as students move from elementary to and through high school. For example, Eccles and colleagues (Eccles & Midgley, 1989; Eccles, Midgley, Wigfield, Buchanan, Reuman, Flanagan & Mac Iver, 1993; Eccles & Roesser, 2009; Wang & Eccles, 2012; see also Booth & Gerard, 2014; Gillen-O'Neel & Fuligni, 2013) have identified significant declines in academic expectancy and valuing between elementary and high school. Once in high school, Martin (2007, 2009) has shown that both motivation and engagement decline as students move from early high school to middle high school and that this follows from higher levels of motivation and engagement in elementary school. Eccles and Midgley (1989) proposed that motivation and engagement decline across the transition from elementary to middle/high school because the developmental needs of adolescents do not fit with the change of context and demands in high school – and nor do instructional approaches adequately meet the needs of the developing learner.

The escalation in demands through school brings into consideration the need to approach instruction in ways that appropriately manage the burden on learners where possible and feasible. Cognitive psychology has been informative in identifying instructional approaches that are directly geared to managing the cognitive load on students to better help them learn and achieve. This article considers numerous instructional approaches that explicitly or implicitly appropriately manage the cognitive burden on students as they learn.

'Load Reduction Instruction' (LRI) is introduced here as an umbrella term that encompasses instructional models such as direct instruction and explicit instruction – as well as some less structured approaches to instruction (e.g. guided discovery learning) – that seek to optimally manage the cognitive burden on students in order to enhance their learning and achievement.

To date, the bulk of research into LRI approaches has focused on their effects for learning and achievement. As discussed in this review, findings support the role of LRI in generating learning and achievement gains. Although learning and achievement are desirable ends in themselves, there are other factors that are considered desirable academic ends. Motivation and engagement are two such factors salient on the psycho-educational landscape. Indeed, from a cognitive psychological perspective, motivation and engagement are recognised as important factors in more complex learning (e.g. Van Merrienboer & Sweller, 2005) and factors that can increase the cognitive resources devoted to a task (e.g. Paas, Renkl & Sweller, 2003).

The present review considers the relationship between motivation, engagement, and LRI. It examines key dimensions of motivation and engagement and explores the extent to which specific approaches and strategies under LRI can address them. In so doing, it seeks to complement the large body of work into LRI and its achievement effects with closer consideration of its potential yields for students' motivation and engagement. Figure 1 presents an overview of the themes and processes addressed herein.

In addressing these issues, the review is organised into five parts.

Part 1. Load Reduction Instruction: (i) definition and description of LRI, (ii) a review of human cognitive architecture as relevant to LRI, (iii) consideration of fluency and automaticity, (iv) a summary of LRI effects on achievement, (v) consideration of LRI for diverse learners and subject areas, and (vi) identification of specific Load Reduction Instructional elements.
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Part 5. Looking Forward: (xii) Opportunities for future research in LRI, explicit instruction, motivation, and engagement.

Load Reduction Instruction (LRI)

Instruction that appropriately reduces or manages the cognitive load on the student in the learning process.

Key elements

(1) Reducing the difficulty of a task during initial learning
(2) Instructional support and scaffolding through the task
(3) Ample structured practice
(4) Appropriate provision of instructional feedback
(5) Independent practice and guided autonomy.

Major instructional approaches

Explicit instruction and guided discovery learning.

Specific instructional strategies

Pre-training; Modelling important processes; Showcasing; Segmenting; Preliminary (and spaced) reviews; Reducing split-attention; Integrating; Information integration sequencing; Harnessing different modalities; Avoiding redundancy; Increasing coherence; Signalling; Organising information thematically; Allowing appropriate instructional time; Checking for understanding; Worked examples; Providing templates; Prompting; Personalising; Deliberate practice; Mental practice; Guided practice; Feedback; Feedforward; Independent practice; Guided discovery learning.

Academic outcomes

Learning, achievement, motivation, engagement.

Figure 1: Organising themes and processes for this review.

PART 1: LOAD REDUCTION INSTRUCTION

Load Reduction Instruction (and Guided Discovery Learning)

Load Reduction Instruction (LRI) is defined here as a mode of teacher-led instruction that involves the following at key points in the learning process:

(1) Reducing the difficulty of a task during initial learning
(2) Instructional support and scaffolding through the task
(3) Ample structured practice
(4) Appropriate provision of instructional feedback, and
(5) Independent practice and guided autonomy (e.g. Adams & Engelmann, 1996; Cromley & Byrnes, 2012; Fisher & Frey, 2008; Magliaro, Lockee & Burton, 2005; Martin, 2013, 2015; Rosenshine, 1986, 2008, 2009; Stein, Carnine & Dixon, 1998; Wood, Bruner & Ross, 1976).

A major tenet of LRI is that learners are at first novices with respect to academic skill and subject matter, that a structured and systemic approach to instruction is important in the early stages of learning, and that there is an appropriate time for guided discovery and exploratory approaches as novices become more developed in their learning (Liem & Martin, 2013; see also Kalyuga, Ayres, Chandler & Sweller, 2003).

Indeed, guided discovery learning can be another means by which to manage cognitive load for the student in the learning process. Accordingly, attention will also be given to the role of guided discovery learning as a part of LRI. As discussed below, following sufficient explicit input, guided practice and demonstration of independent learning, there is an important place for guided discovery learning, including with regards to motivation and engagement (Liem & Martin, 2013; Martin, 2013). Once learners progress beyond novice status and have sufficiently automated core skills and knowledge, they are ready to engage in meaningful discovery and exploratory learning that have motivational properties beyond the motivational yields experienced through LRI. LRI thus recognises that explicit and constructivist learning and teaching are inextricably intertwined such that the effectiveness of one is reliant on the effectiveness of the other.

Although other frameworks have recognised the roles of both explicit and discovery approaches (e.g. 'balanced instruction', 'gradual release of responsibility', 'enhanced discovery learning', 'differentiated instruction' etc; e.g. Alfieri, Brooks, Aldrich & Tenenbaum, 2011; Fisher & Frey, 2008; Marzano, 2011; Maynes, Julien-Schultz & Dunn, 2010; Pearson & Gallagher, 1983; Pressley & Allington, 2014; Tomlinson, 2001), LRI is distinct in that its emphasis is on reducing or managing the cognitive burden on students as they learn. LRI is thus termed, framed, and developed deliberately to indicate why we engage its various instructional elements – namely, to deliver instruction and instructional support so as to appropriately reduce and manage the cognitive burden on the learner.

The cognitive architecture of the human mind: Working and long-term memory

When developing instructional approaches for students, it is important to understand the cognitive parameters relevant to learning. The architecture of the human mind – and its memory systems – is one of the core foundations underpinning the rationale for LRI approaches. This has implications for the development and delivery of LRI – as well as the ordering and balancing of explicit instruction and guided discovery learning.

Working and long-term memory are primary mechanisms for learning (Kirschner, Sweller & Clark, 2006; Sweller, 2012; Winne & Nesbit, 2010). Working memory refers to the conscious component of cognition responsible for receiving and processing information, performing tasks, solving problems, etc. – particularly new information, new tasks, and novel problems. Learning is believed to occur when information is successfully moved from working memory and stored in long-term memory (Kirschner et al., 2006; Sweller, 2012; Winne & Nesbit, 2010). Figure 2 shows the process, with stimuli received by the sensory register (e.g. sound, sight, touch etc.) sent to working memory, information in working memory is encoded and sent to long-term memory, and information in long-term memory is retrieved to working memory to be applied as necessary.

If working memory is overly burdened or overloaded then there is a heightened risk that instructional content is not understood, information is misinterpreted or confused, information is not effectively encoded in long-term memory, and learning is markedly slowed down (Rosenshine, 1986, 2009; Tobias, 1982). Given this, there is a need to deliver instruction, present instructional material, and organise learning tasks that do not overly or unnecessarily burden students' working memory (Kirschner et al., 2006).

It is also the case that working memory is limited. Indeed, because a major function of working memory in the classroom is to process novel, unfamiliar information that comes from others (via listening, observing, or reading), working memory limits are highly relevant at many points of the learning process. This presents a substantial challenge to teachers as effective instruction relies on them navigating this limited conscious aspect of the cognitive structure (working memory) when teaching new material and presenting novel subject matter (Sweller, Ayres & Kalyuga, 2011; Winne & Nesbit, 2010). It has been speculated that information stored in working memory has a capacity of about seven elements (or even as low as four elements plus or minus one element). Further, this can be lost within about 30 seconds unless rehearsed (Baddeley, 1994). Clearly, a vast body of instructional material comprises information that exceeds seven (or so) elements or requires the student to be able to retain extended or complex concepts in conscious working memory for more than 30 seconds. This reality has led to research and theory into instructional approaches that aim to accommodate the boundary conditions inherent in learners' working memory systems.

Fortunately, long-term memory does not have the same limitations as working memory. Long-term memory has vast capacity. Thus, if information can be effectively and accurately stored in long-term memory and if working memory can efficiently access this long-term memory, successful learning can take place. Given this, there is a clear necessity to deliver instruction and develop instructional material that optimally assists the processing of information to long-term memory from working memory, the processing of information from long-term memory to working memory, and a working memory that is freed from unnecessary burden or load (Martin, 2015; Paas et al., 2003; Sweller, 2003, 2004; Winne & Nesbit, 2010).

From a cognitive load perspective, learning thus very much relies on building long-term memory and effectively managing working memory to facilitate this (Kirschner et al., 2006; Sweller, 2012; Winne & Nesbit, 2010). According to Kirschner and colleagues: 'Any instructional theory that ignores the limits of

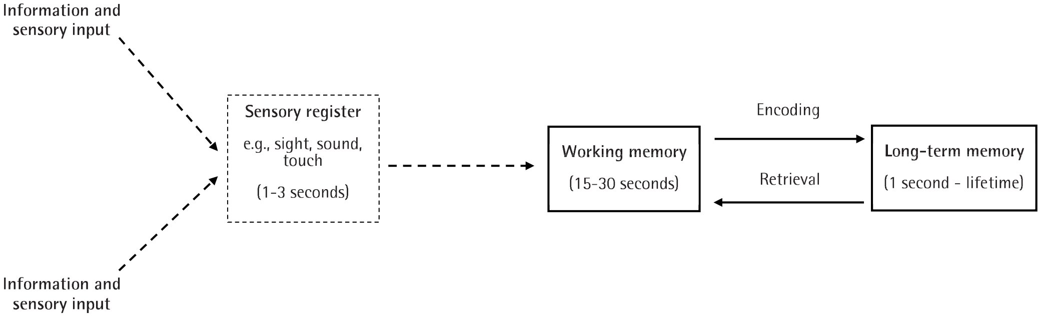

Figure 2: Process of sensory, working, and long-term memory.

working memory when dealing with novel information or ignores the disappearance of those limits when dealing with familiar information is unlikely to be effective' (2006, p.77).

Indeed, cognitive load theorists suggest three goals for designing learning: reduce extraneous cognitive load, manage essential cognitive processing, and foster generative processing (Mayer, 2004; Mayer & Moreno, 2010; Moreno & Mayer, 2010). In all cases, it is recognised that cognitive capacity is limited and so it is important to reduce load on learners in order to facilitate the learning process. Notably, when dealing with familiar, organised information held in long-term memory, there are no known capacity or duration limits on working memory. Thus, students are transformed when information is transferred to long-term memory and this explains why education is transformative (Sweller, 2012).

Fluency and automaticity

According to Rosenshine (1986, 2009), fluency and automaticity are vital means of reducing the burden on working memory. This occurs when information is effectively stored in long-term memory and is accessed by working memory fluently and seemingly automatically. This frees up working memory that can then be used to process new information to long-term memory, to apply one's learning, or for higher order thinking and guided discovery learning (Rosenshine, 1986, 2009). That is, as long-term memory builds and automaticity develops, the learner is ready for greater discovery, exploration, and inquiry approaches to instruction. The pedagogical approach traversing this process is herein referred to as LRI.

Indeed, it is claimed that it is this automaticity that demarcates novice learners from expert learners. Expert learners derive and build their skill by drawing on the extensive information stored in long-term memory and quickly selecting and applying it to solve new problems (Kirschner et al., 2006). Accordingly, the aim of education is to increase the information held in long-term memory and this is achieved through instruction that optimises the capacity of working memory and long-term memory to process new information efficiently.

Automaticity also demarcates the student who struggles academically from the student who does not (Martin, 2015). There are some students for whom working memory (or related executive functions) is impaired. These students are more likely to be cognitively overloaded than students without such impairments. Especially for these academically at-risk students, it is important that teachers implement instructional approaches that reduce the burden on working memory.

Accommodating the boundary conditions of human cognitive architecture as relevant to learning thus relies on the teacher to structure learning material and learning activities in a way that reduces ambiguity, enhances clarity, builds in sequencing, and harnesses scaffolds. In so doing, the teacher manages the learning and instruction process in a way that optimises learner and learning efficiency. Notably, recent developments in cognitive psychology that have been applied to educational processes provide guidance on how material can be organised and presented to learners to free up working memory, optimise long-term memory, and enhance the processing of information from long-term to working memory – and in so doing, realise the aims of instruction intended to reduce the cognitive burden on students (Winne & Nesbit, 2010). However, as discussed below, as fluency and automaticity develop, the cognitive load inherent in instruction may be upwardly adjusted (e.g. via independent and guided discovery learning) to match the developing expertise of the learner.

Load Reduction Instruction and evidence: Learning and achievement

In numerous empirical studies, meta-analyses and reviews, the achievement-related merits of LRI approaches are evident (Cromley &

Byrnes, 2009; Lee & Anderson, 2013; Liem & Martin, 2013; Mayer, 2004). Across numerous subject domains and skill sets to be learned, LRI is positively associated with learning and/or achievement (e.g. see Cooper & Sweller, 1987; Klahr & Nigam, 2004; Matlen & Klahr, 2010; Strand-Cary & Klahr, 2008; Sweller & Cooper, 1985).

In early work, Adams and Engelmann (1996) examined the effectiveness of major educational approaches (including those aligned with LRI) on numerous educational outcomes. Findings showed that explicit instruction, for example, yielded consistently positive effects on basic skills (e.g. word recognition, spelling, math computation) and cognitive skills (e.g. reading comprehension, math problem solving). Positive effects were also observed for motivational factors and affective outcomes (e.g. self-concept, attributions to success).

In a meta-analysis by Haas (2005), the most effective method of teaching algebra was deemed to be explicit instruction. Its effectiveness was attributed to the focus on appropriate pacing and both guided and independent practice. Borman and colleagues (2003) conducted a meta-analysis of numerous school reform programs. They found that explicit instruction evinced the strongest systematic evidence of effectiveness. In a meta-analysis across 304 explicit (direct) instruction studies, Hattie (2009) ranked explicit instruction 26th out of 138 effects on achievement, placing it 'among the most successful outcomes' (p.205).

Meta-analysis by Alfieri and colleagues (2011) showed that the specific techniques emphasised under LRI-oriented frameworks moderated the effects on achievement. For example, worked examples yielded the strongest results, followed by feedback, direct teaching, and explanations. When reviewing the range of meta-analyses conducted over the past two decades, Liem and Martin (2013) concluded that LRI approaches that allow teachers to be 'activators' of student learning (Hattie, 2009) are well placed to alleviate cognitive demands and assist working memory and long-term memory to effectively process instructional material (see Alfieri et al., 2011; Kirschner et al., 2006).

An examination of evidence across a range of students

In assessing the feasibility of any instructional approach, it is important to examine its effectiveness across different types of learners. For example, if LRI is to be implemented in the classroom, it is important to show that its effects are positive across the range of students that typically reside in that classroom. Indeed, this range comprises (inter alia) students of high, average and low ability, students with specific learning disabilities (e.g. dyslexia) or executive function deficits (e.g. ADHD), and students at-risk on the basis of such factors as socio-economic status (Martin, 2015).

Low and high performers

Adams and Engelmann (1996) argue that low and high performers are not qualitatively different. There are relatively few mistakes among low performers that high performers are not at risk of making. Instead, variation seems to be in the degree and amount of a particular instructional approach that is appropriate for low and high performers: 'Work with students of different abilities reveals that higher performers require less repetition, fewer examples, and often less reinforcement than lower performers. Lower performers may have concept and skill deficiencies that the higher performers of the same age do not have, and these deficiencies require time to remedy' (Adams & Engelmann, 1996, p.28; see also Tarver, 1998; Tarver & Jung, 1995; Vitale & Romance, 1992).

Accordingly, if a complex skill (e.g. reading) is able to be taught to lower performers, the main difference from high performers is that it tends to be easier and faster to teach to higher performers (Adams & Engelmann, 1996): 'Given that both the higher performer and the lower performer do not know a particular skill, however, and given that both start about the same level of naiveté, both would have to learn the same information, operations, or processes' (p.29). Hence the main instructional variation would be the pace of the presentation of information, the relative weight given to the core steps in explicit instruction, and the speed at which they would be moved onto guided discovery and independent learning.

Academically at-risk students

Students who are academically at-risk will be particularly challenged – and potentially disadvantaged – with the escalation of curriculum and the cognitive load this places on them (Martin, 2015). In the 'regular' classroom, for example, cognitive demands will be especially salient for students with executive function disorders (i.e. disorders such as impairments to working memory, planning, organisation) such as attention-deficit/hyperactivity disorder (ADHD) as well as for students with specific learning disabilities such as dyslexia, dyscalculia and the like. Further, because these types of disorders are co-morbid with other disorders, it is not uncommon that at-risk students will experience more than one cognitive difficulty (Cantwell & Baker, 1991; Tabassam & Grainger, 2002). For example, estimates suggest that approximately one-third of students with specific learning disabilities also have ADHD (Hallahan, 1989; Robins, 1992). Carmichael and colleagues (1997) found ADHD in around half of students diagnosed with a specific learning disability. McKinney and colleagues (1993) found co-occurrence over 60 per cent. If the effects of LRI (or any form of instruction for that matter) are not positive for such at-risk students, then there is a danger that an unanticipated consequence of its implementation is to create and/or widen achievement gaps.

In relation to at-risk students, it has been claimed that they can have difficulty understanding or identifying many of the subtleties of instructional material and the 'hidden structure' of learning (Ewing, 2011). By making all elements of learning explicit, less is hidden. Consistent with this, LRI-oriented practices have been found to be effective for special education students (Forness, 2001; Forness, Kavale, Blum & Lloyd, 1997). In a meta-analysis by Swanson and Sachse-Lee (2000), substantial variance in academic outcomes for students with learning disabilities was related to instructional strategies involving drill-repetition-practice-review procedures as well as appropriate segmentation of material. They concluded, 'regardless of the practical or theoretical orientation of a study, treatments that included the aforementioned instruction components yielded high effect sizes' (p.129; see also McMullen & Madelaine, 2014; Rupley, Blair & Nichols, 2009).

Similarly, in a review of meta-analyses of students in special education services by Forness (2001), only four meta-analyses met the criterion for large achievement-related effect sizes, one of which related to explicit/direct instruction. In other meta-analyses of students with learning disabilities and LRI-oriented practice, Swanson et al. (1996) and Swanson and Hoskyn (1998) found large effect sizes for achievement, as did Hattie (2009) for special education students.

With regards to 'core' skills such as literacy and numeracy, LRI has been effective for academically at-risk students. In the area of literacy for students with learning disabilities, Jitendra and colleagues (2004) found significant gains maintained over time and Mastropieri and colleagues (1996) found large effect sizes for reading comprehension. Similar positive results were found for at-risk students and reading achievement (Carlson & Francis, 2003; see also Kamps, Abbott, Greenwood, Wills, Veerkamp & Kaufman, 2008). For mathematics achievement and learning disabled students, Kroesbergen and Van Luit (2003) and Gersten and colleagues (2009) derived moderate to large effect sizes for load reduction techniques. In reviewing such findings, Purdie and Ellis (2005) concluded the results: 'clearly demonstrate that teaching approaches based on direct instruction and strategy instruction produce positive effects for students with learning difficulties' (p.21; see also Farkota, 2003).

Low socio-economic status

Socioeconomic status is another dimension through which students can be placed at academic risk (Sirin, 2005). In terms of diverse socio-demographic groups, LRI approaches have shown efficacy for students low in socio-economic status and those who are geographically marginalised. For example, Stockard (2010) showed that explicit instruction is effective in helping low socio-economic students overcome the late elementary school slump typical of many students not exposed to enriched contexts. Stockard (2011) also showed that reading among rural students is significantly enhanced through LRI approaches, with their reading scores above national average following explicit instruction.

An examination of evidence across a range of subject areas

The effectiveness of LRI must also be demonstrated across a range of subjects taught in the typical educational context, including the so-called 'concrete' subjects such as mathematics and the less 'structured' subjects such as English. To the extent that LRI can be demonstrated to be effective across this range of subjects, its educational validity can be further established. With respect to LRI-oriented practice, explicit instruction has been found to be effective for learning and achievement in subjects such as reading as well as in subjects such as mathematics (Hattie, 2009). In a review of mathematics programs, Przychodzin-Havis and colleagues (2004) found results favoured explicit instruction in the majority of studies reviewed. In a subsequent publication (2005) on reading, they also identified the effectiveness of explicit instruction across most studies. In a review of reading mastery, findings favoured LRI approaches (Schieffer, Marchand-Martella, Martella, Simonsen & Waldron-Soler, 2002).

Load Reduction Instructional elements

Thus far, the review has focused broadly on LRI as an approach to pedagogy, the cognitive rationale for its effectiveness, and supportive evidence for diverse learners and subject areas. As with any instructional approach, it is the component elements of LRI that drive its specific and concrete operationalisation. These core elements are what address the limits of working memory, optimise storage in long-term memory, and enhance processing between the two.

Across many decades of research, spanning cognitive and educational psychology, there emerges some commonality in the key or especially effective elements of instruction that can reduce the burden on students' working memory. As noted above, these elements are intended to facilitate the processing of information as relevant to the functions of working and long-term memory – and thereby reduce cognitive load. As relevant to the present review, they are also a means by which to assess the role of LRI in fostering student motivation and engagement.

It will be recalled that LRI involves the following at some point in the learning and achievement process:

(1) Reducing the difficulty of a task during initial learning
(2) Instructional support and scaffolding through the task
(3) Ample structured practice
(4) Appropriate provision of instructional feedback, and
(5) Independent practice and guided autonomy.

These represent a useful organising framework for considering key elements of LRI. Here, these elements are briefly introduced. In a section to follow, they are described in detail, including how they may assist academic motivation and engagement.

(1) Reducing the difficulty of a task during initial learning
    Pre-training
    - Teacher provides early instruction on the core elements of a task (e.g. identifying name, definition, location, function of topics or components) to assist subsequent learning

Modelling important processes

- Teacher demonstrates how to complete a task; can also involve 'think-aloud' strategies as the teacher conducts a task

Showcasing

- Teacher shares examples of good practices and good work to provide clarity on what constitutes good work and how to do it

Segmenting

- Teacher breaks a task into 'bite-size' components (or 'chunks') and encourages students to see the completion of each component as a success

Preliminary (and spaced) reviews

- Teacher and students review prior learning at the outset of a new task or lesson; teacher reviews at regular (spaced) intervals (e.g. review prior week's learning at the start of each week)

(2) Instructional support and scaffolding through the task

Reducing split-attention

- Two or more stimuli are integrated where feasible to reduce splitting students' attention across disparate stimuli (e.g. integrate the equation for finding an angle into the angle itself on a given diagram)

Integrating

- Teacher integrates the focus of a learning task with a meaningful problem (e.g. integrate instruction on punctuation into a student's own essay)

Information integration sequencing

- Teacher integrates two successive pieces of instructional material into the one instructional element (e.g. integrate the narration of how lightening is formed with an animation of that process)

Harnessing different modalities

- Teacher presents different pieces of information (or stimuli) in a different modality (e.g. present an image with a narrative in order to reduce the burden on visual and auditory processers)

Avoiding redundancy and increasing coherence

- Where possible, teacher presents information once (avoiding redundancy) and organises material so that extraneous or overly elaborate material that may be tangential to essential learning is reduced or removed (increasing coherence)

Signalling

- Teacher provides cues to help the learner locate and focus on the essential material in a lesson or activity (e.g. teacher asks students to watch out for a particular event or character in a plot)

Organising information thematically

- Teacher identifies a major/main theme in a task or learning activity and explicitly connects instruction to this theme

Allowing appropriate instructional time

- Teacher schedules tasks and lessons to ensure sufficient instructional time occurs in a task, in a lesson, and across the day

Checking for understanding

- Teacher employs checking strategies such as frequently posing questions and asking students to summarise major points or repeat explanations

Worked examples

- New material is presented to learners with completed samples of work that show how a particular problem can be solved or task is to be completed

Providing Templates

- Materials are provided to learners that are formatted or structured to help the learner stay on track or that list the important features to include or address in a task

Prompting

- Learners are strategically prompted to persist with and complete less structured tasks such as those found in comprehension and writing tasks (e.g. students are asked to identify the 'what', 'who', 'why', and 'when' in a stimulus passage; this helps them extract specific information or articulate an answer or response)

Personalising

- Teacher adjusts wording and/or administration of a task to involve the learner in a more personalised and individually-relevant way (e.g. Use instructions such as 'Your goal in this task is to …' rather than 'The goal for this task is to …')

(3) Ample structured practice

Deliberate practice

- Teacher ensures rehearsal that is relevant to a specific skill, usually also involving feedback, and conducted by the student on his/her own

Mental practice

- Learners imagine or mentally rehearse a concept or procedure (e.g. the student studies an example, then turns away and rehearses the example in his/her mind)

Guided practice

- Learners are systematically guided through the steps of learning or problem solving (e.g. prompting responses through a task or providing part of a solution for a student to complete)

(4) Appropriate provision of instructional feedback

Feedback

- Concrete and specific information is provided on the correctness of an answer or the quality of application

Feedforward

- Concrete and specific information is provided on how the answer or quality of the application can be improved in future schoolwork

(5) Independent practice and guided autonomy

Independent practice

- When skills and knowledge become automated and fluent, the learner is encouraged to attempt similar problem tasks independently

Guided discovery learning

- When the learner has engaged in successful independent practice, he/she is encouraged to undertake new tasks, move in new directions, or apply learning to 'real-world' problems that further enrich learning.

(For research and reviews supporting identification of these elements, see for example: Adams & Engelmann, 1996; Atkinson, Derry, Renkl & Wortham , 2000; Cromley & Byrnes, 2012; DeRuvo, 2009; Farkota, 2003; Ginns, Martin & Marsh, 2013; Hattie, 2009, 2012; Hunter, 1984; Lee & Anderson, 2013; Liem & Martin, 2013; Martin, 2013, 2015; Marzano, 2003, 2011; Mayer & Moreno, 2010; Nandagopal & Ericsson, 2012; Nuthall, 1999; Purdie & Ellis, 2005; Renkle, 2014; Renkl & Atkinson, 2010; Rosenshine, 1986, 1995, 2009; Schute, 2008; Sweller, 2012; van Gog, Ericsson, Rikers & Paas, 2005; Van Merriënboer & Sweller , 2005; Wiliam, 2011).

The present review draws on each of these key elements of LRI-oriented approaches and considers how each one may impact students' motivation and engagement. In doing so, the aim is to extend the large body of work into LRI that has focused on its achievement effects to also consider it in terms of its motivation and engagement yields. To the extent that plausible connections can be made, LRI may be considered an instructional approach that not only has learning and achievement benefits, but also benefits for students' academic motivation and engagement.

PART 2: MOTIVATION AND ENGAGEMENT

It is evident that LRI approaches have achievement-related merit for a wide range of students, including for academically at-risk students. It is also evident that LRI can be effective for achievement across diverse curricular domains. Relatively less attention has been directed to LRI and academic motivation and engagement. The limited body of research has suggested positive connections between the two (e.g. for research and reviews see Adams & Engelmann, 1996; Bessellieu, Kozloff & Rice, 2001; Farkota, 2003; Reeves, 2010; Tarver, 1998; Van Keer & Verhaeghe, 2005). However, when motivation and engagement are addressed in LRI research, they tend to be considered as part of a range of outcome variables (i.e. not the focus of the research study), and typically they are positioned as somewhat secondary to achievement. It is also the case that motivation and engagement research has incorporated LRI perspectives. However, this work tends to represent LRI as part of a range of pedagogical approaches (e.g. Bost & Riccomini, 2006; Cromley & Byrnes, 2012; Guthrie & Davis, 2003; Wigfield, Guthrie, Perencevich, Taboada, Klauda, McRae & Barbosa, 2008; Wigfield, Guthrie, Tonks & Perencevich, 2004); that is, LRI is not often the main focus in motivation and engagement research. There is thus a need to purposefully focus on motivation and engagement factors and formally assess the extent to which LRI approaches might address them.

Multidimensional motivation and engagement

Motivation and engagement are defined here as students' inclination, interest, energy, drive, and effort to learn, work effectively, and achieve to potential (Liem & Martin, 2012; Martin 2007, 2009; Pintrich, 2000, 2003; Reschly & Christenson, 2012; Schunk & Miller 2002; Schunk, Pintrich & Meece, 2008). Concerns have been raised that the diversity of motivation and engagement theories and factors has left educational psychology overly fragmented. Accordingly, there have been calls for more cohesive and integrative approaches to motivation and engagement theorising and research (e.g. Bong, 1996; Murphy & Alexander 2000; Pintrich 2003; Reeve, 2015; Reschly & Christenson, 2012).

One recent integrative effort has led to the development of a multidimensional model of motivation and engagement, referred to as the Motivation and Engagement Wheel (Martin, 2007, 2009) – shown in Figure 3. Although the Wheel is the focus in this review, there are other examples of multidimensional motivation and engagement frameworks and instrumentation such as that reflected in the Patterns of Adaptive Learning Survey (PALS) by Midgley and colleagues (1997), the Motivated Strategies for Learning Questionnaire by Pintrich, Smith, Garcia, and McKeachie (1991), the Student Engagement Instrument (SEI) by Appleton, Christenson, Kim, and Reschly (2006), and the Inventory of School Motivation (ISM) by McInerney, Yeung, and McInerney (2000).

The Motivation and Engagement Wheel

There are three primary concepts underpinning the Wheel. The first is that motivation and engagement factors can be demarcated into 'internal' (or intrapsychic) and 'external' (or behavioural) factors. The second is that these factors can be demarcated into adaptive and maladaptive dimensions. The third is that there are seminal motivation theories important to represent.

With regards to the 'internal' and 'external' dimensions of motivation and engagement, recent reviews of motivation and engagement have identified this as a common theme through the literature (see Martin, 2012b; Martin, Ginns & Papworth, 2016 for reviews). Reeve (2012) has noted that motivation comprises 'private, unobservable, psychological, neural, and biolog-

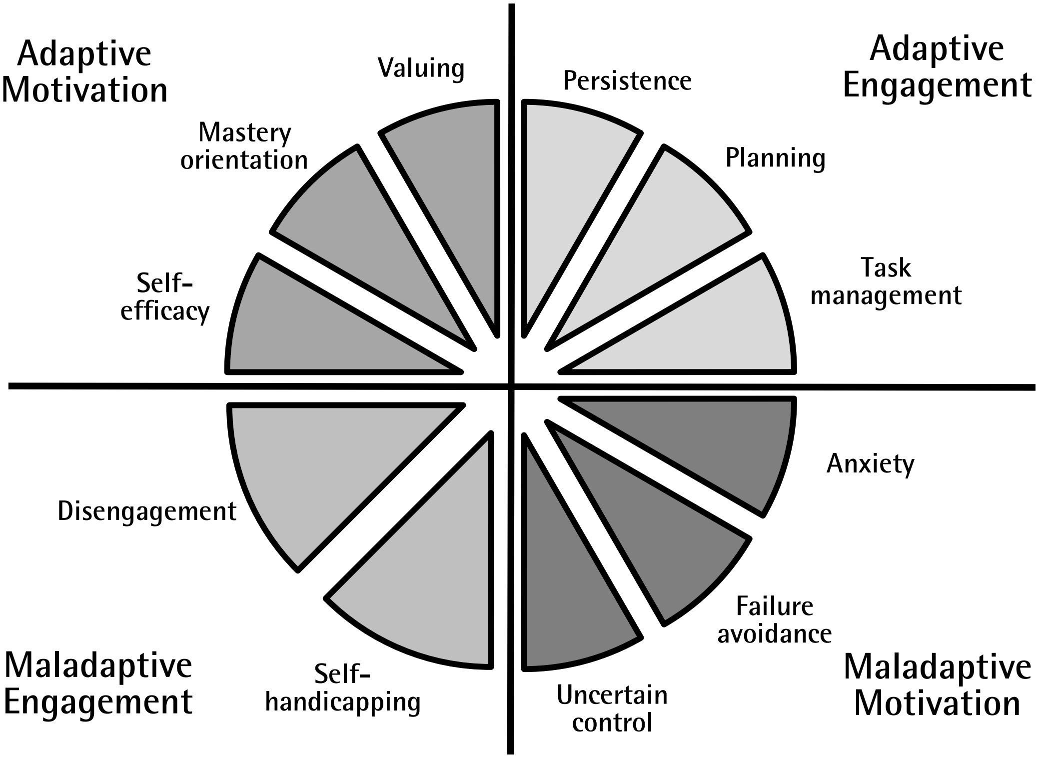

Figure 3: The Motivation and Engagement Wheel. Reproduced with permission from A.J. Martin and Lifelong Achievement Group (www.lifelongachievement.com).

ical' factors whereas engagement comprises 'publicly observable behaviour' (p.151). Cleary and Zimmerman (2012) identified engagement as comprising observable (behavioural) and internal (cognitive and affective) factors. Ainley (2012) posits motivation as an inner psychological factor and engagement as a factor reflecting involvement in a task or activity. Anderman and Patrick (2012) demarcate engagement into its emotional, cognitive and behavioural terms (also see Fredicks et al., 2004 for a detailed review). Schunk and Mullen (2012) describe motivation as an internal force that energises engagement. Voelkl (2012) identifies affective and behavioural factors in the literature and reports motivation as aligning with the former and engagement aligning with the latter. Taken together, these authors suggest in one way or another that motivation and engagement can be demarcated into 'internal' and 'external' (or observable) forms. Accordingly, the Wheel is demarcated into motivation (primarily cognitive; but also emotional) that represents the 'internal' and engagement (behavioural) that represents the 'external'.

In relation to adaptive and maladaptive dimensions of motivation and engagement, it is the case that, for the most part, a good deal of motivation and engagement research and theory emphasises positive constructs and positive constructions. However, it has been suggested that a dual approach to motivating and engaging students is required: enhance adaptive motivation and engagement and reduce maladaptive motivation and engagement (Martin, 2012b; Martin, Anderson, Bobis, Way & Vellar, 2012). Accordingly, Martin and colleagues (2012) recommended that the study of motivation and engagement requires attention to both adaptive and maladaptive dimensions. Their research operationalised persistence at school in terms of the joint forces of 'switching on' (engagement) and 'switching off' (disengagement). They found that although the two are significantly correlated (negatively), they also each accounted for unique variance in the academic process. Accordingly, the Wheel comprises both adaptive and maladaptive dimensions of motivation and engagement.

With regards to seminal psycho-educational theory, Pintrich (2003) identified key substantive issues critical to address as motivational science develops. He emphasised the importance of considering and conceptualising motivation in terms of seminal theorising relevant to: self-efficacy (and related expectancies), valuing, goal orientation, self-determination, self-regulation, attributions, control, need achievement, and self-worth. In line with this, there are numerous theories and conceptual frameworks describing and explaining academic motivation and engagement, including self-efficacy and agency perspectives (Bandura, 1997, 2001) that suggest inclusion of a self-efficacy factor; expectancy-value theory (Wigfield & Eccles, 2000) suggesting a valuing factor; goal theory (Elliot, 2005) suggesting approach (mastery orientation) and avoidance (failure avoidance) goal factors; self-determination theory (Deci & Ryan, 2012; Ryan & Deci, 2000) suggesting core psychological needs such as competence (self-efficacy); self-regulatory theories (Zimmerman, 2002) suggesting planning, task management, and persistence factors; attribution and related control theories (Connell, 1985; Weiner, 2010) suggesting a control (or, conversely, uncertain control) factor; and need achievement and self-worth motivation theories (Covington, 1992, 1998, 2000) suggesting anxiety, self-handicapping and disengagement factors.

Accordingly, as Figure 3 demonstrates, the Wheel is organised into higher-order and lower-order factors. The higher order factors reflect the internal/external and adaptive/maladaptive tenets of motivation and engagement. The lower order factors reflect multidimensional psycho-educational theorizing suggested by Pintrich (2003). The four higher order factors are adaptive cognition, sometimes referred to as adaptive motivation (lower-order factors: self-efficacy, valuing, mastery orientation); adaptive behaviour, sometimes referred to as adaptive engagement (lower-order factors: planning and monitoring behaviour, task management, persistence); maladaptive cognition, sometimes referred to as maladaptive motivation (lower-order factors: anxiety, failure avoidance, uncertain control); and maladaptive behaviour, sometimes referred to as maladaptive engagement (lower-order factors: self-handicapping, disengagement). Each of these factors is briefly defined (following Martin, 2007, 2009, 2010) as follows:

Adaptive motivation:

- *Self-efficacy* is students' belief and confidence in their ability to understand or to do well in schoolwork, to meet challenges they face, and to perform to the best of their ability.
- *Valuing* is how much students believe what they learn at school is useful, relevant, meaningful, and important.
- *Mastery orientation* refers to students' interest in and focus on learning, developing new skills, improving, understanding, and doing a good job for its own sake and not just for rewards or the marks they will get for their efforts.

Adaptive engagement:

- *Persistence* refers to how much students keep trying to work out an answer or to understand a problem, even if that problem is difficult or challenging.
- *Planning (and monitoring)* refers to how much students plan assignments, homework and study and, how much they actively keep track of their progress as they do this work.

- *Task management* refers to how students use their study or homework time, organise a study or homework timetable, choose and arrange where they study or do homework, and increasingly, how they manage their digital world (e.g. self-regulation and impulse control with regards to mobile technology while doing schoolwork).

Maladaptive motivation:

- *Anxiety* has two parts: feeling nervous and worrying. Feeling nervous is the uneasy or sick feeling students get when they think about or do their schoolwork, assignments, or tests. Worrying refers to fearful thoughts about schoolwork, assignments, or tests.
- *Uncertain control* reflects students' uncertain or low sense of control, typically when they are unsure how to do well or how to avoid doing poorly.
- *Failure avoidance* refers to a motivation to do one's schoolwork in order to avoid doing poorly, to avoid being seen to do poorly, or to avoid the negative consequences of poor performance.

Maladaptive engagement:

- *Self-handicapping* refers to behaviours that reduce students' prospects of success at school (e.g. waste time, procrastinate, do little or no study, misbehave in class) in order to establish an alibi or excuse in case they do not perform well.
- *Disengagement* refers to thoughts and feelings of giving up, trying less each week, detachment from school and schoolwork, feelings of helplessness, and little or no involvement in class or school activities.

The Motivation and Engagement Scale

The conceptually-oriented Motivation and Engagement Wheel (Martin, 2007, 2009) is accompanied by multidimensional measurement instrumentation – the Motivation and Engagement Scale (MES; Martin, 2016) – that is used to assess each of the eleven factors. There are four items per factor, yielding 44 items for the MES, each rated on a 1 (Strongly Disagree) to 7 (Strongly Agree) scale. The MES (and select subscales within it) has demonstrated sound factor structure, high factor loadings, reliable factors, invariance as a function of age and gender, and external validity with other educational and personality factors and processes (e.g. Bodkin-Andrews, Denson & Bansel, 2013; Bugler, McGeown & St Clair-Thompson, 2015; Edgar, 2015; Ginns, Martin, Liem & Papworth, 2014; Liem & Martin, 2012; Martin, 2007, 2009; Martin, Anderson, Bobis, Way & Vellar, 2012; Martin, Papworth, Ginns & Liem, 2014; Martin, Yu, Papworth, Ginns & Collie, 2015; Nagabhushan, 2012; Plenty & Heubeck, 2011, 2013; Tinker & Elphinstone, 2014; Wurf & Croft-Piggin, 2015; Yeung, Barker, Tracy & Mooney, 2013). The MES has also been validated in other countries such as China, the US, Canada, Jamaica, and the UK (Martin & Hau, 2010; Martin, Martin, & Evans, 2016; Martin, Yu & Hau, 2014; Yin & Wang, 2015).

PART 3: LOAD REDUCTION INSTRUCTION, MOTIVATION, AND ENGAGEMENT

Having identified key facets of multidimensional motivation and engagement (via the Wheel) and the key elements of LRI (via the LRI framework 1. Reducing task difficulty … 5. Independent practice), it is possible to conduct a nuanced analysis of how the two are connected. The approach adopted here is to consider each of the 11 parts of the Motivation and Engagement Wheel and identify which of the key LRI elements are likely to promote them. Essentially, then, the aim is to identify how the motivation and engagement elements in the first column (Column A) of Table 1 are associated with the LRI elements in the second column (Column B) of Table 1.

Importantly, in considering the links between motivation, engagement and LRI, it is emphasised that these links are indicative and suggestive, not prescriptive or definitive. Importantly also, in addition to the links proposed here, there are other plausible links between LRI elements and different parts of the Wheel (e.g. guided discovery learning might also be connected to mastery orientation). The point of this review is to identify channels of aligned relevance between key elements of LRI and major motivation and engagement factors. As noted later in this review, empirical work is needed to ascertain which specific LRI strategies might explain most variance in distinct motivation and engagement factors. Findings from these empirical investigations will further illuminate, add to, and potentially qualify some of the links suggested herein.

Self-efficacy

The promotion of self-efficacy involves restructuring learning so as to maximise opportunities for success (such as through individualizing tasks where possible; McInerney, 2000; Schunk & Miller, 2002), addressing and enhancing students' (oftentimes negative) beliefs about themselves and their competence (Beck, 1976, 1995; Meichenbaum, 1974; Wigfield & Tonks, 2002), developing skills in effective goal-setting (Locke & Latham, 2002), and breaking work into manageable and doable 'chunks' (Martin, 2007). Such approaches are aimed at addressing cognition and/or optimizing opportunities for success that provide a basis for enhancing one's self-efficacy (McInerney, 2000). With regards to key elements of LRI, four are particularly well-suited to promote these processes and outcomes: pre-training, segmenting and organising information, conducting preliminary and spaced reviews, and modelling.

Pre-training

Self-efficacy builds as learning and competence develop (Bandura, 2001; McInerney, 2000; Schunk & Miller, 2002). Learning and competence are facilitated via access to a sufficient amount of prior knowledge (Mayer & Moreno, 2010). For example, if teaching students how a motor works, there may be some pre-training on the main parts of a motor (name, location, function of part/s) that will assist subsequent learning and competence (referred to as the 'pre-training principle'; Mayer & Moreno, 2010, or depending on how and when information is presented, the 'isolated elements effect'; Pollock, Chandler & Sweller, 2002). Pre-training develops prior knowledge (stored in long-term memory) which occupies fewer working memory resources, leaving more working memory to acquire new knowledge as the motor (for example) is explained more fully. Taken together, pre-training helps maximise the information held in students' long-term memory, helps organise information that makes it easier to understand, and strengthens connections between working memory and long-term memory (Rosenshine, 1995). Pre-training thus enhances memory systems that underpin learning and competence, and by implication, helps lay a foundation for a sense of efficacy relevant to this learning and understanding.

Table 1: The Motivation and Engagement Wheel and Load Reduction Instruction (LRI) elements.

A. Motivation and Engagement Wheel factors	B. Load Reduction Instruction (LRI) elements
Adaptive motivation ■ Self-efficacy ■ Valuing ■ Mastery orientation	**(1) Reducing the difficulty of a task during initial learning** ■ Pre-training; Modelling important processes; Showcasing; Segmenting; Preliminary (and spaced) reviews
Adaptive engagement ■ Planning and monitoring behaviour ■ Task management ■ Persistence	**(2) Instructional support and scaffolding through the task** ■ Reducing split-attention; Integrating; Information integration sequencing; Harnessing different modalities; Avoiding redundancy; Increasing coherence; Signalling; Organising information thematically; Allowing appropriate instructional time; Checking for understanding; Worked examples; Providing templates; Prompting; Personalising
Maladaptive motivation ■ Anxiety ■ Failure avoidance ■ Uncertain control	**(3) Ample structured practice** ■ Deliberate practice; Mental practice; Guided practice
Maladaptive engagement ■ Self-handicapping ■ Disengagement	**(4) Appropriate provision of instructional feedback** ■ Feedback; Feedforward
	(5) Independent practice and guided autonomy ■ Independent practice; Guided discovery learning

Pre-training may particularly benefit novice or at-risk learners. Here, the teacher may provide additional instruction to some students prior to embarking on new units of learning. This further ensures that essential terms and basic skills required for a unit of work are known by these students. The teacher takes some additional time to develop this important prior knowledge to better ensure it is stored in long-term memory to help working memory process new incoming information (Mayer & Moreno, 2010) and to ensure the connection between new information and prior knowledge is clearer. In sum, then, novices and academically at-risk students can have difficulty in the early phases of learning (Martin, 2015) and this is likely to impede their sense of efficacy throughout the learning process (Martin, 2012a). Pre-training enables a stronger beginning to the learning process and potentially surer footing from a self-efficacy perspective.

Segmenting information

Martin (2003, 2005, 2010) has identified the importance of competence as a basis for building self-efficacy and ‘chunking’ as one effective strategy to achieve this. Chunking involves: (a) breaking a task into more manageable ‘chunks’ and (b) seeing the completion of each chunk as a success. The first element helps students see the task as doable and the second element builds competence and efficacy into the process of completing the task (Martin, 2003, 2005, 2010). This aligns closely with ‘segmenting’ in the explicit instruction literature. Segmenting is a way to deal with information that is complex, multi-part, or substantial.

Here the teacher breaks larger units into more achievable segments and systematically presents this information as the learner grasps the previous segment (referred to as the 'segmenting principle'; Mayer & Moreno, 2010; Rosenshine, 1995).

Interestingly, in multimedia scenarios, learning effectiveness is further enhanced when the pacing from one segment to another is under the learner's control (i.e. self-paced; Mayer & Moreno, 2010). This signals the importance of the learner's self-determination through the process. Segmenting can also be adapted to individual students by adjusting the size and number of information segments presented. Thus, for expert learners, fewer and larger segments may be feasible whereas for novice learners, more and smaller segments may be desirable. In the above-mentioned multimedia example (where the pace from one segment to another is in the learner's control), the expert learner can move at a brisker pace while novice learners can move at a slower pace.

Preliminary and spaced reviews

Reviewing prior learning and instruction helps students activate prior knowledge and understand the subject matter, building competence, and thus improving or sustaining their sense of efficacy (Marzano, 1998). Review thus forms a mechanism that not only reinforces the prior knowledge itself, but also affirms to the learner that he/she has the requisite knowledge and skill, thus promoting self-efficacy. Review can be very important at the outset of a lesson in order to reacquaint learners with prior knowledge or material covered in a previous lesson (Hattie, 2009, 2012). According to Rosenshine (1986, 2009), teachers adopting LRI approaches will commence a lesson with about five minutes reviewing relevant prior knowledge. This might include reviewing mathematics formulas or workings, reading sight words, revisiting chemical equations, and so on (see also Hunter, 1984).

Review also has relevance at appropriately spaced intervals to reinforce learning that will have occurred prior to the previous lesson or lessons. For example, Rosenshine (1986, 2009) advises weekly and monthly review. In earlier advice, Good and Grouws (1979) suggested teachers review the previous week's work every Monday and the previous month's work every fourth Monday. It is also important to recognise that the value of review depends heavily on the quality of the instructional processes that have occurred before it (Stein et al., 1997). That is, students will require high quality prior knowledge and a meaningful skill-set that the spaced review is designed to reinforce. Spacing is also considered a form of 'desirable difficulty' (Bjork, 1994) in that it stretches a student beyond immediate repetition (that is less difficult) to a more demanding act of review at a later time (more difficult; see also Bjork & Allen, 1970; Cepeda, Pashler, Vul, Wixted & Rohrer, 2006). For example, it may be relatively easy to recall or reproduce algebraic knowledge immediately following work on algebra problems. However, recalling or reproducing algebraic knowledge one or more weeks later requires more effortful and demanding cognitive application and processing.

Modelling

Bandura (1997, 2001) makes clear the yields of students observing efficacious behaviour by relevant/significant others to assist the development of their own efficacy. Modelling relevant behaviours and processes by teachers is thus a means for developing students' efficacy. Thus, for example, teachers might demonstrate in a passage of text how they would use procedural prompts to summarise key and relevant information in that text (Hunter, 1984; Rosenshine, 1995). Another modelling strategy is for the teacher to engage in 'think aloud' exercises. This allows the novice (student) to observe how an expert (teacher) thinks through a process that is otherwise hidden from the student (Rosenshine, 1995; see also Biggs & Telfer, 1987). The novice is then better able to reproduce that function and thereby build efficacy following from this sense of competence.

Modelling can be adapted in the classroom to make the most of the opportunities a typical classroom composition may offer. For example, in addition to the teacher engaging in think-aloud exercises to provide insight into how an expert thinks through a mathematics problem (for example), there may be opportunities for more advanced learners to also provide think aloud examples as they work alongside novice learners (Rosenshine, 1995). Or, more developed learners may demonstrate to novices how they read a comprehension passage using procedural prompts (such as 'who', 'what', 'when', 'why') to comprehend or summarise it. In each case, modelling is used to build efficacy in the novice learner. As described below, worked examples (Sweller, 2012) can play a similar role in modelling a problem solving procedure.

Valuing (school and schoolwork)

Central to students' valuing (of school and schoolwork) is their view that school is relevant, useful, meaningful, connected to their lives now and/or in the future. Students' valuing of academic subject matter, tasks, and activities also relies on the perceived personal relevance, importance and utility of that material (Wigfield & Eccles, 2000). Valuing is further developed through connections students can make between prior and current learning and also between learning and larger issues that have broader importance and relevance (Martin, 2010). Three elements of LRI have potential to promote these processes and yields: integrating, organising segments, and personalising.

Integrating

Integrating stimuli is one strategy that can be used to promote connections between different facets of the learning task. The more connections students can see among tasks and subject matter, the greater their sense of relevance with regards to the learning material or task (Martin, 2003, 2010). For example, punctuation is often taught in isolation from students' editing of their own essays and assessment tasks. In such cases, an opportunity to build a sense of relevance with regards to punctuation is lost. Integration might involve students being presented with an explicit punctuation check list (e.g. capitalise the start of a sentence, end questions with a question mark etc.) that they work through after they have written an essay. Thus, there is structured and scaffolded support for punctuation built into the student's own essay writing activity that increases the perceived relevance and personal meaning associated with the punctuation activity.

Notably, integration is the reverse of some approaches to pre-training and segmenting described above, especially with regards to the 'isolated elements effect' (Pollock et al., 2002). Whether elements should be isolated or integrated depends on available working memory resources that in turn depend on levels of knowledge (Sweller, 2012) – further underscoring the importance of pre-training if and when needed. Notwithstanding this, as a general principle, integration of information, materials, and/or activities allows students to better appreciate important connections in learning and thus the value of the relevant information, materials, and activities for other parts of their learning.

Organising information thematically

Pre-training and integration are focused on connections among specific elements of subject matter. Thus, they are focused on relatively 'local' and proximal connections. Valuing of school and subject matter is also achieved by connecting to 'big ideas' and more general or indeed, global issues. By connecting school to broader issues and phenomena outside of school, school is more meaningfully located in a broader scheme, again enhancing its perceived relevance (Martin, 2010). This can involve instruction via identification of and guidance using a 'big idea' (Stein et al., 1998).

In history, for example, by using a 'problem-solution' theme many historical events can be taught for better understanding, learning, and relevance. Helping students understand the causes underlying historical events such as war can be assisted through unifying segmented information under a 'problem (multiple possible causes: e.g. economic, religious, human rights) – solution (multiple solutions: e.g. war, migrating, tolerating, innovating)' framework (Stein et al., 1998). Another application in history involves the 'problem-solution-effect" theme that 'people and governments are reacting to problems, that the causes of those problems are small in number; and there are a few common solutions to those problems' (Kinder & Bursuck, 1992, p.29). Kinder and Bursuck then analyse World War I and World War II to highlight this theme. Graphic organisers such as concept maps can also be helpful to link to big themes and ideas that more meaningfully connect academic subject matter to the broader world. These display segments in a way that make clear the link between the instructional material and a 'big idea' central to the course, topic, or task (Rosenshine, 1995).

In each of these examples, there is a 'big idea' that is a basis for effectively organising instructional material (also helpful for working and long-term memory storage and processing; Mayer & Moreno, 2010) and making explicit connections between academic subject matter and these broader and potentially universal themes. These connections improve students' valuing of school and schoolwork (McInerney, 2000). As with integration, thematic organisation is the reverse of some approaches to pre-training described above, especially with regards to the 'isolated elements effect' (Pollock et al., 2002). Again, whether elements should be isolated or positioned under a 'big idea' will depend on available working memory resources (Sweller, 2012) – again emphasising the importance of pre-training and segmenting if and when needed.

Personalising

Personal relevance is central to learners' valuing of subject matter (and subjects and school more broadly; Martin, 2010; McInerney, 2000). Material and information can be presented in a way that better draws the learner into the activity and fosters personal meaning and connection with that material and information. The 'personalisation principle' holds that learners receiving information in a more personalised way will learn more than those receiving information in a more detached, objective, and unnecessarily-formal way. Thus, instructions such as, 'Your goal in this task is to …' leads to more meaningful learning than instructions such as, 'The goal for this task is to …'. Recent meta-analysis supports this principle (Ginns, Martin & Marsh, 2013), finding that personalisation of subject matter and tasks is associated with perceived friendliness, effective cognitive processing, and significant retention and transfer. Similarly, experimental studies have also shown the positive impact on learning and motivation through inclusion of personally-relevant facts into instruction (Cordova & Lepper, 1996; Ku & Sullivan, 2002; Walkington, 2013).

Mastery orientation

Mastery orientation is very much concerned with students' focus on the task at hand, focus on learning and understanding, and the effort required in the process (Midgley, Kaplan, Middleton & Maehr, 1998). Relative to performance orientation (that is focused on reward, competition, external and comparative standards), mastery orientation reflects more an intrinsic approach and orientation with a focus on and immersion in the inherent properties of tasks and learning (Anderman & Wolters, 2006; Elliot, 2005; Linnenbrink-Garcia, Tyson & Patall, 2008; Maehr & Zusho, 2009). Relative to performance goals, mastery goals tend to be associated with greater learning and engagement outcomes (Martin & Elliot, 2016; Yu & Martin, 2014). Notwithstanding this, the effects of each orientation may differ according to where a student is at in the learning process. For example, performance orientation may be adaptive for surface learning of facts and content, whereas mastery orientation may be superior for deeper and inferential learning (e.g. Linnenbrink-Garcia et al., 2008). In any case, the literature generally supports the merits of mastery over performance orientation in the learning process (Elliot, 2005; Maehr & Zusho, 2009; but see Senko & Miles, 2008). To the extent that this is the case, the use of signalling, independent practice, deliberate practice, and guided discovery learning are suggested as LRI elements that may align with or promote students' mastery orientation.

Signalling

Often learning material is complex and cannot be structured in a way to minimise or avoid cognitive load. In such cases, other instructional devices can be used. Signalling is one such device that involves providing cues to help the learner locate and focus on the essential material in a lesson or activity (referred to as the 'signalling principle'; Mayer & Moreno, 2010; see also De Koning, Tabbers, Rikers & Paas, 2009). For example, the teacher may ask the students to watch out for a particular event or character in a plot, the teacher may place an emphasis on particular words in the instructional process, headings may be used to orient the learner to an important idea, highlighters may be used to orient the learner to key words and concepts, or advance organisers may be developed that make clear at the outset what major concepts or activities are to be addressed (Mayer & Moreno, 2010).

Each practice is aimed at reducing cognitive load by eliminating the need for the learner to search for relevant or essential material. Importantly, from a motivation perspective, signalling also makes explicit the task-relevant information and demands, the importance of focusing on task elements, and emphasising task and learning concerns (as distinct from performance concerns). In these ways, it is suggested that signalling is fostering mastery orientation as well.

Independent practice

A major aim of explicit, structured, and supported instruction is to develop some level of fluency and automaticity in learning. When fluency and automaticity are developed, knowledge and skills have been committed to long-term memory and the learner can access and produce this material relatively rapidly and with relative ease. It is at this stage the learner is now ready for more independent application.

In the early stages of independent practice, this process is confined to the material, tasks, and activities that have been the focus of LRI (Rosenshine, 1986, 2009). For example, if students are learning about the components of a paragraph in an essay (e.g. comprising a good opening sentence, relevant specific detail and evidence and argument, and a summative or linking sentence to close the paragraph), this is the focus of independent practice. It is also important for the teacher to move around the classroom to monitor students' independent practice (Hunter, 1984). Rosenshine (1986) suggests that if contact with the student is necessary during this stage, it should be kept brief, averaging no more than 30 seconds for each interaction. Again, the emphasis is on independence.

From a cognitive perspective, this reinforces fluency and automaticity. Notably, from a motivation perspective, independent practice also promotes an autonomy supportive learning environment. In the educational context, autonomy support refers to climates and instruction that promote students' volition, autonomy, and intrinsic motivation (Collie, Shapka, Perry & Martin, 2015; Deci & Ryan, 2012; Ryan & Deci, 2000). These are elements aligned with or contributing to students' mastery orientation given the emphasis of mastery on individual and personal motivation (Martin & Elliot, 2016). Notably, however, the autonomy-promotive elements of independent practice are likely to hold only to the extent that they foster a mastery orientation. If students are asked to independently practice without a good reason or rationale, or when the practice is mindless, they may fail to make the connection between effort and outcome (violating a critical concept under mastery orientation; e.g. Elliot, 2005), and they may not personally endorse the activity (violating their autonomy, also a critical concept under mastery orientation and intrinsic motivation; Collie et al., 2015; Deci & Ryan, 2012).

Deliberate practice

Deliberate practice refers to rehearsal relevant to a specific skill that is correctable. It usually involves repetition and feedback and at critical points it is conducted by the student on his/her own (Nandagopal & Ericsson, 2012; Purdie & Ellis, 2005). Skills are often practiced under close supervision of a teacher and activities are well-defined, goal-directed and involve substantial feedback (Nandagopal & Ericsson, 2012). According to Hattie (2012), 'deliberate practice requires concentration, and someone (either the student, or a teacher, or a coach) monitoring and providing feedback during the practice' (p.110). Deliberate practice is different from mindless drill. Mindless drill might involve students writing many complete essays in order to finesse their essay's introduction or other specific aspects of the essay. Doing so does not expose them to enough targeted practice needed to master the introduction itself. Deliberate practice would involve specific rehearsal with appropriate constructive feedback on the introduction alone (see also Ericsson, 2014; Ericsson & Pool, 2016).

According to Nuthall (1999), students need about four exposures to content (no more than two days apart) to sufficiently integrate it into their knowledge structure (see also Marzano, 2003). It is evident, then, that deliberate practice is not necessarily a comfortable process. Inevitably, it creates dissonance between where a learner currently sits and a level of performance, automaticity, and fluency to which he/she aspires. This 'requires full concentration and is effortful to maintain for extended periods. Students do not engage in deliberate practice because it is inherently enjoyable, but because it helps them improve their performance' (Van Gog et al., 2005, p.75).

When the relevant skills are mastered, the student is better able to engage in solitary practice of activities, setting their own goals and practice routines, and learning how to pace and self-manage through this process. Further, deliberate practice helps to foster a mastery orientation by reminding students that their practice efforts are linked to their performance outcomes. When practice is deliberate, mastery orientation is emphasized because students set practice aims and make the connection between their efforts and outcomes by monitoring their progress towards practice goals.

Guided discovery learning

Liem and Martin (2013) suggest that after sufficient direct input and guided, independent, and deliberate practice, there is then a place for guided discovery learning. That is, having moved students through the independent and deliberate practice phase and being satisfied that they have mastered the material and its attendant processes, the teacher then transitions students into a guided discovery learning phase. Now that learners have progressed beyond novice status, they possess the sufficient skills and concepts to engage in more open-ended discovery approaches. Proponents of explicit approaches to instruction thus recognise that guided discovery has a vital place in the learning process (e.g. Mayer, 2004). For example, having mastered one paragraph during independent learning, students may now be asked to write two linked paragraphs integrating the various skills or processes learnt during guided and independent practice. Or, it may involve the application of one's learning to 'real-world' problems (e.g. Van den Heuvel-Panhuizen & Drijvers, 2014) with appropriate support as needed.

Guided discovery learning also entails a modest elevation in task challenge and brings into consideration concepts such as 'desirable difficulty' (Bjork, 1994) that suggests appropriate points in the learning process where more difficult tasks lead to greater learning than continued presentation of easy tasks. Indeed, this notion of graduated challenge is consistent with findings in other lines of educational research. For example, research into personal best (PB) or growth goals has articulated the role of setting personally challenging targets (Elliot, Murayama, Kobeisy & Lichtendfeld, 2014; Elliot, Murayama & Pekrun, 2011; Martin & Elliot, 2016; Martin & Liem, 2010; Yu & Martin, 2014). Findings suggest that students who set personally challenging goals evince adaptive patterns of motivation, engagement, and achievement (Martin & Elliot, 2016; Martin & Liem, 2010; Yu & Martin, 2014). The 'Goldilocks effect' is also aligned with this notion of optimal difficulty and challenge. This refers to individuals' preference to attend to tasks and activities that are neither too easy nor too difficult (Kagan, 1990). Guided discovery learning is well suited to this principle.

From a motivation perspective, independent practice lays a foundation for autonomy support, intrinsic motivation, and hence, mastery orientation. Guided discovery learning provides another opportunity to immerse students in the intrinsic and inherent properties of the task, thereby further developing their mastery orientation. Moreover, the very clear emphasis on discovery rather than performance further distances students from a performance orientation and more closely locates them in mastery-oriented terrain.

Planning (and monitoring) and task management

Planning and task management are very much concerned with students' self-regulated learning skills (Zimmerman, 2002). These functions, residing under the self-regulatory umbrella, rely on students' capacity to organise material, pace their learning appropriately, identify and attend to the steps involved in learning, self-monitor and appropriately adjust as required (Martin, 2007, 2009, 2010). Mental practice, guided practice, and worked examples are proposed as elements of LRI that have potential to enhance students' planning, monitoring, and task management.

Mental practice

Related to deliberate practice is the process of 'mental practice' (sometimes referred to as the 'imagination effect'; Sweller, 2012). Here, learners are asked to imagine or mentally rehearse a concept or procedure. The mental rehearsal occurs in working memory and this assists in the transfer of information to long-term memory by constructing and automating schemata (Sweller, 2012). Research asking students to study a worked example and then to turn away and rehearse the example in their mind found these students performed better than the students who studied worked examples but were not asked to further mentally consider the concept (Sweller, 2012).

The 'planning and monitoring' component of the Wheel relies on the learner's capacity to mentally represent the various demands before him/her. This mental representation might involve the components of a particular task or the key parts of a schedule of activities (Martin, 2010). Further, the extent to which learners are able to monitor their progress will very much depend on how well this representation is stored in long-term memory. Mental practice may be an ideal means of helping learners better mentally represent what they are required to do and the steps involved in doing it – all key to planning and monitoring from a motivation and engagement perspective.

Worked examples

Worked examples involve presenting new material to learners with completed samples of work that show how a particular problem can be solved or how a task can be completed.

Teachers would ask students to study numerous worked examples showing how different types of problems can be solved. Research shows that worked examples help learners acquire schemas that they can then apply to solve problems quickly and efficiently (Atkinson et al., 2000; Renkle, 2014; Renkl & Atkinson, 2010; Rosenshine, 1986, 1995, 2009; Sweller, 2012). Worked examples might include fully worked mathematics solutions, sample essays, and completed science practicum reports. In their review of instructional methods, Lee and Anderson (2012) were struck by the power of providing examples of problem solutions to assist learning. Indeed, they went so far as to suggest that discovery-based approaches are effective to the extent that they are example-based.

As learning develops, the student is presented with partially completed worked examples to solve (referred to as the "problem completion effect"; Sweller, 2012). Ultimately, the worked examples are fully faded and learners are ready for completely unworked tasks and problem solving (Mayer & Moreno, 2010; Sweller, 2012) that may be ideal for guided discovery opportunities.

It is also the case that more developed learners (experts) do not need such substantial exposure to worked examples. They may study just one worked example before proceeding to a partially worked example, or to a fully unworked problem itself (Sweller, 2012). The 'guidance fading effect' (or 'guided activity principle') is apparent when the effectiveness of worked examples slowly fades, requiring learners to complete more of the problem task themselves to extend learning (Moreno & Mayer, 2010; Renkl & Atkinson, 2010; Sweller, 2012).

Research has also identified the effectiveness of teachers eliciting students' self-explanations of what they are doing or why they have selected a particular response as they engage in partially completed examples. Asking for self-explanations during partially completed worked examples takes advantage of the reduced cognitive load (and freed cognitive capacity) created by the worked example (Renkl & Atkinson, 2010; Rosenshine, 1986, 2009). This has been referred to as 'self-explanation' or the 'reflection principle' which helps learners connect new learning with prior knowledge in long-term memory (Moreno & Mayer, 2010).

Not only are worked examples effective in enhancing long-term memory and easing the load on working memory as new information or tasks are learned, they are also effective in promoting planning, monitoring, and task management. Specifically, worked examples explicitly identify the components of a task that the learner will need to plan for in their own task completion, emphasise the elements that are important to monitor in order to stay on task, and provide a clearer sense of what components and processes are involved in order to effectively manage the task demands.

Guided practice

A related process is guided practice (Hunter, 1984). Here students are systematically guided through the steps of learning or problem solution. This can involve prompting responses through a task, providing part of a solution for a student to complete, or being readily available for questions and guidance at each step (Rosenshine, 1986, 2009). Importantly, it seems that teachers should strive to ensure a reasonably high success rate during this process, with the optimal success rate on assigned tasks or activities approximately 75-80 per cent during guided practice. Thus, the teacher's task is to combine success with reasonable challenge (Rosenshine, 1986, 2009). In so doing, the student moves through learning material at a reasonable pace, experiences efficacy as he/she progresses, but makes sufficient errors to enable corrective feedback and new learning (Martin, 2007). As with worked examples, guided practice makes explicit the components of a task to be performed or learning to be achieved. Knowing these components is important for a student's capacity to plan what he/she is to accomplish through the task, monitor and pace through the task, and manage the process to completion – again, all critical foundations for planning, monitoring, and task management.

Persistence

Persistence refers to students' continued efforts in the face of large tasks, task difficulty, initial error or misunderstanding, or uncertainty as to the requirements or steps in a task (Martin, 2007, 2010; Miller, Greene, Montalvo, Ravindran & Nichols, 1996). LRI strategies that teachers might implement to enhance and sustain students' persistence include: checking for understanding, using templates, and using procedural prompts. These are aimed at keeping students efficaciously involved in the process (e.g. by ensuring they understand), and ensuring they have a clear understanding of task requirements and what is required to persist through them.

Checking for understanding

According to Hattie (2009, 2012), effective teachers tend to see assessment as an opportunity for feedback to them about the effectiveness of their pedagogy. Similarly, Rosenshine (1986, 2009; see also Hunter, 1984) reports that effective teachers dedicate ample time to checking for student understanding and engage in checking strategies that are qualitatively superior to other teachers. For example, they will frequently pose questions, ask students to summarise major points, repeat explanations and directions, and ask students' opinions on subject matter as it is taught. These teachers tend not to ask non-specific questions (such as 'Are there any questions' or 'Who doesn't understand?') and tend not to call on volunteers to check for student learning. Instead, they will ask questions to individual students and these questions are appropriately tailored (by difficulty or substance) to each student to more authentically gauge understanding (Rosenshine, 1986, 2009).

Some have suggested using simple tools to check student understanding as the lesson proceeds. For example, students might record quick responses to teacher questions on small white boards for the teacher to know if he/she can proceed or if some reteaching is required (DeRuvo, 2009). Similarly, the 'traffic light' formative assessment signalling method is another widely advocated and implemented technique (Black, Harrison & Lee, 2004). Here, students present a red card to indicate 'I don't understand' or 'I need help', a yellow card to indicate 'I think I understand' or 'I may need a bit of help', and a green card to indicate 'I understand'. DeRuvo (2009) suggests that to keep a brisk pace, it may also be appropriate to allow brief or abbreviated answers as the aim is often to simply check for understanding, not require students to articulate full responses.

Adams and Engelmann (1996) have provided guidelines on acceptable levels of accuracy that can be a basis for checking that students have sufficiently understood. They suggest teachers check that students are at least 70 per cent correct on core information and knowledge from the preceding lesson and nearly 100 per cent correct on core information and knowledge presented in that lesson. However, these guidelines may vary depending on the student and the subject matter. Others have suggested more frequent intra-lesson assessment to check for student understanding. Black and colleagues (2004; see also Black & Wiliam, 2004), for example, found substantial gains from intra-lesson formative assessment and feedback in mathematics and science. 'Rapid formative assessment' (Wiliam, 2011) has also been suggested three to five times each week (see also Hattie, 2012).

Collectively, these efforts are aimed at ensuring students remain on task, are in touch with the run of the lesson and understand what is being taught, thereby enhancing engagement and connection through the task or lesson and reducing the potential inclination to give up, lose track, or switch off. Accordingly, persistence through a task and through a lesson is promoted. These efforts may also foster the belief that persistence leads to results. This belief may be an important regulatory mechanism that guides students to persist, indeed, suggesting something of a 'persistence self-concept' or 'persistence schema' that may further promote perseverance through a task or lesson.

Templates

Sometimes persistence is a problem for students when they get stuck or lost midway through a task. In such cases, it may be useful to provide templates for students to check their own progress. For example, students can have difficulty editing their own work and may abandon efforts to do so (Collie, Martin & Scott-Curwood, 2015). Templates are materials formatted or structured to help the learner stay on track or that list the important features of an essay or report to include. This may be a checklist that asks the student to check that each sentence begins with a capital letter, all sentences end with a punctuation mark, proper nouns are capitalised etc. (Stein et al., 1998). The student checks off each element as it is completed and this checklist may also be submitted with the essay or report for assessment. A similar strategy has been suggested by Van Merriënboer (1992) using 'process worksheets' that lists the steps involved in completing tasks or solving problems. As students work through the process, they check off each step as it is achieved. Some teachers may write abbreviated instructions in bullet-form on the board for students to refer to as they progress (DeRuvo, 2009). In each case, there is a mechanism in place to assist a student through a task to completion. In so doing, the teacher has promoted a student's persistence.

Prompts

Procedural prompts have been suggested by Rosenshine (1995; see also Purdie & Ellis, 2005) as a cognitive strategy that helps learners to persist with and complete less structured tasks such as those found in comprehension and writing activities. The most common procedural prompts are words such as 'what', 'who', 'why', and 'when' that help students extract specific information from text and provide prompts they can use to articulate an answer or response. This too is aimed at facilitating effort and persistence in the face of blockages that can arise in the course of learning and task completion.

Anxiety, failure avoidance, and self-handicapping

Anxiety is associated with reduced or limited working memory span (Ashcraft & Kirk, 2001; Eysenck & Calvo, 1992). It has been suggested that intrusive thoughts, distractions, frustration, and negative emotional /affective experiences may act as a source of extraneous cognitive load and tap the limited capacity of working memory (referred to as the 'processing efficiency theory'; Eysenck & Calvo, 1992; see also Fraser, Huffman, Ma, Sobczak, McIlwrick, Wright & McLaughlin, 2014; Kalyuga, 2011). Further, it has been suggested that anxiety operates much like a dual task setting, comprising a preoccupation with one's fears as well as a resource-demanding secondary task (Ashcraft & Krause, 2007). Thus, alongside anxiety is the issue of fear of failure (or, failure avoidance concerns) that may pervade a task, potentially further burdening working memory.

Researchers have also identified that anxiety and fear of failure underpin students' tendency to self-handicap. Self-handicapping refers to self-defeating behaviour (e.g. procrastination, wasting time, investing little or no effort) that can provide a self-worth protecting excuse or alibi in the event of poor performance (Baumeister & Scher, 1988; Covington, 1992, 1998, 2000; Martin, Marsh & Debus, 2001a, 2001b, 2003; Martin, Marsh, Williamson & Debus, 2003; Midgley, Arunkumar & Urdan, 1996; Rhodewalt & Davison, 1986; Thompson, 1994). It has been established that poor performance risks a threat to one's self-worth, particularly if that poor performance is seen as due to a lack of ability (Covington, 2000). Thus, when a student is anxious or fearful that he/she may fail a task, the student may strategically manoeuvre so that the poor performance is seen as due to a lack of effort (not so threatening to self-worth) rather than a lack of ability (threatening to self-worth).

Motivation researchers have identified educational intervention strategies and approaches to alleviate anxiety, fear of failure, and self-handicapping (e.g. Covington, 1992, 2000; Martin, 2007, 2010; McInerney, 2000; McInerney, Marsh & McInerney, 1999; Pintrich & DeGroot, 1990). However, the connection between anxiety, fear of failure, self-handicapping and working memory suggests LRI approaches (that reduce load on working memory) may also play a part in addressing these maladaptive factors. Alongside the numerous strategies described above that are aimed at easing working memory or improving processing between working and long-term memory, reducing split attention in a task as well as integrating information sequencing are other approaches to reduce the burden on working memory. In so doing, the teacher may also assist in reducing anxiety, fear of failure, and the consequent motive to self-handicap. Or, it may be that even if a student does experience the negative impact of anxiety on working memory, effective uses of LRI will reduce this impact.

Reducing split-attention

LRI very much rests on learning material that is carefully structured by the teacher. When material is poorly structured, there can be excessive load on working memory, thereby impeding learning – and potentially increasing anxiety and fear of failure that may sow the seeds of self-handicapping (Covington, 2000; Thompson, 1994). The 'split attention effect' represents one way material can be poorly structured. Here, information to solve a problem is presented in more than one area of the learning space (Ginns, 2006; Mayer & Moreno, 2010; Sweller, 2012). For example, a diagram is presented at the top of a page or screen and explanatory material required to interpret the diagram is presented elsewhere on the page or screen. Working memory is strained because the learner must hold information in working memory from one part of the learning space to understand the material in the other part of the learning space. This splits the attention capacity, is inefficient, and increases cognitive load (Sweller, 2012) that may elevate anxiety. It is therefore important for material to be integrated wherever possible – not only to reduce cognitive load for learning, but also to reduce anxiety and fear processes.

For example, the mathematics teacher might integrate the equation for finding an angle into the angle itself. Or, the science teacher may integrate a physics equation into a problem statement (Sweller, 2012). Structuring learning material and processes mindful of split attention effects (and modality effects, see below) is particularly critical to novices and students of lower ability (Sweller, 2012). When students are beginning to learn new concepts, working memory comes under most strain and thus instructional design should place emphasis on strategies that reduce load on working memory (Sweller, 2012).

Information integration sequencing

Just as material presented at different places in the learning space can split attention and overload working memory, material presented at different points in time can also burden working memory (referred to as the 'temporal contiguity effect'; Mayer & Moreno, 2010). For example, in a multimedia exercise demonstrating lightning, if the first part of the instruction provides a narration of how lightening is formed and this is then followed by an animation of that process, this requires the learner to hold one piece of information (the narration) in working memory to then integrate with the next piece of information (the animation). Integrating narration and animation into the one piece of information removes this excessive load. This would involve providing narration to accompany each part of the animation as it is presented. In this case, information integration sequencing would help reduce load on working memory. To the extent it reduces such load, it also has potential to reduce anxiety and fear that may develop as the learner struggles to manage the excessive cognitive demands.

Uncertain control

Uncertain control reflects a student's uncertainty as to how to perform a task, uncertainty as to whether his/her efforts will lead to success, a lack of perceived autonomy, and a potential sense of helplessness that may arise as a result of this uncertainty and lack of autonomy (Abramson, Seligman & Teasdale, 1978; Connell, 1985; Martin, 2007, 2010; Skinner, 1996; Weiner, 1985). Motivational intervention aimed at promoting a sense of control involves encouraging students to see the connection between their effort and strategy (both controllable elements of their schoolwork) and academic outcomes. Developments in self-determination theory (SDT) have also identified the important role of structure in autonomy-supportive environments (e.g. Reeve, Deci & Ryan, 2004; Sierens, Vansteenkiste, Goossens, Soenens & Dochy, 2009). A sense of control can be further enhanced by providing feedback in effective and consistent ways. This often involves task-based feedback on students' work that is clear about how they can improve (Craven, Marsh & Debus, 1991; Martin et al., 2001b). Numerous LRI approaches are also effective in providing a greater sense of how to accomplish tasks, being autonomy-supportive, and providing feedback that is aimed at enhancing clarity and performance. Two approaches discussed here are showcasing and feedback (and feedforward).

Showcasing

LRI is geared to taking the mystery out of what good work is and how to do it. There are many opportunities for teachers to showcase examples of good practices and good work that can provide clarity to students and enhance their sense of control through a task. DeRuvo (2009), for example, suggests explicit instruction on teaching students how to take notes in class. This might involve giving five-minute instruction on a concept and then distributing a sample notes page that shows what information has been recorded and how to record it quickly and accurately. The teacher then presents the five-minute instruction again, but more slowly as students study the notes recorded on the page.

During this instruction, students might also be taught how to use symbols and shorthand for common words such as 'and', 'since/because', 'change', 'therefore', 'between', 'increase/decrease', and the like. Indeed, a table of these might also be provided and exercises assigned for the student to practice and memorise these in order to automate them in long-term memory. Here, students' sense of control is built by showing them how to perform the core academic task of note-taking and automating this for future application. As students' academic lives are increasingly digital and technological, similar such approaches may be adapted to showcase how to type effective class notes on their laptops or tablets in class.

Indeed, this somewhat structured approach is not inconsistent with suggestions under SDT that have identified the importance of assistive structure in promoting autonomy-supportive environments that in turn promote students' sense of autonomy (Reeve et al., 2004; Sierens et al., 2009), one indicant of perceived control (Skinner, 1996). In fact, Sierens et al. found that the interaction between structure and autonomy support (high structure, high autonomy support) leads to enhanced engagement, suggesting an important synergy between structure, motivation, and engagement.

Showcasing can also involve students closely studying samples of good work. For example, teachers may provide all students with a copy of an excellent (anonymised) science practicum report from the previous year. The teacher then dedicates a lesson to unpacking each section of the report, identifying why and how the report is an excellent work sample. The teacher might then present a partially worked example of a science report and ask students to complete this worked example to practice key components. Here, a sense of control is built by showcasing good work, identifying key elements of good work, and having students engage in practice that helps automate the skills involved.

Feedback and feedforward

In one way or another, feedback represents a major part of LRI-oriented models. It is also established as a major means by which students' sense of control can be developed. This is because feedback provides diagnostic information on what students have done, makes clear what elements are to be retained going forward, and what needs to be improved in subsequent tasks (Martin, 2010). Outcomes are further optimised when the provision of feedback is matched by the learner's willingness and capacity to receive and act on the feedback (Algiraigri, 2014).

In addition, following the positive link between structure and students' sense of autonomy (an indicant of perceived control; Skinner, 1996) described above, Sierens et al. (2007) have suggested that feedback is another means by which students' autonomy can be promoted: teachers building appropriate structure into their lessons tend to do so via competence-relevant feedback and feedback that communicates a confidence in students' capacity to achieve on subsequent learning tasks and activities (Connell, 1990; Reeve et al., 2004). Indeed, given this future-oriented dimension to feedback, the term 'feed-forward' has been suggested (e.g. Basso & Belardinelli, 2006; Dowrick, Kim-Rupnow & Power, 2006; Dowrick, Tallman & Connor, 2005).

Moreno and Mayer (2010) report that feedback providing: (a) information on the correctness of an answer and (b) information on how performance can be improved leads to better performance and motivation. Kulik and Kulik (1979) found that immediate feedback is ideal and that doing further study and assessment if performance does not reach a pre-determined criterion is also ideal in the feedback process.

Schute (2008) conducted a wide-ranging review of feedback, deriving the following recommendations from analysis of theory and research: focus feedback on the task, not the learner; provide elaborated feedback in order to enhance learning; present elaborated feedback in manageable segments; ensure feedback is clear and specific; provide feedback that is as simple as possible, but no simpler (the latter will be based on learner needs and instructional constraints); deliver feedback that is unbiased, objective, and ideally in written form or via computer; and, promote a motivation to attain mastery via the feedback. In all cases, the objective is to create greater task-related clarity about the learner's performance in one task (thus, feedback) and provide greater clarity about how to perform the next task (thus, feedforward). In so doing, learners develop a heightened sense of control.

In Schute's (2008) review, guidance was also provided on how to administer feedback for different types of learners. For high achievers: delayed feedback, facilitative (not directive) feedback, or verification feedback (i.e. whether they are on track) may be appropriate. For low achievers: immediate feedback, specific feedback, directive or corrective feedback, scaffolded (supporting) feedback, and elaborated feedback (i.e. why they are correct) are more appropriate.

Rosenshine (1986, 2009) also suggested how feedback can be useful for differentiation in the classroom. If a student is correct and confident, the teacher can respond 'very good' and move on to maintain the momentum of practice and the development of automaticity. If the student is correct but hesitant, or has a history of difficulty, the teacher may confirm the answer is correct but then also provide process feedback that explains how or why the answer is correct. For students who have made an error or continually struggle, the teacher might not only provide feedback, but also simplify the question, provide hints and prompts, or reteach the material.

In sum, these feedback (and feedforward) efforts and suggestions can provide students with important diagnostic information about what they have done, make salient what knowledge and skills are to be retained going forward, and what needs to be improved in subsequent tasks (Martin, 2010). In so doing, they provide clarity and direction to students that are important for promoting perceived control.

Disengagement

Disengagement is complex and can arise for many reasons (Finn & Zimmer, 2013). It may be that the student lacks particular skills in a domain such as literacy or numeracy, or self-regulation skills such as study and organisational skills (Covington, 1992, 2000). In some cases there are motivational problems such as low self-efficacy (Bandura, 2001), low valuing of the domain or tasks within it (Wigfield & Eccles, 2000), or uncertain control leading to helplessness (Abramson et al., 1978; Weiner, 1985). From a cognitive psychology perspective, it may be a function of the instruction or task itself that over-burdens some learners' cognitive capacity or renders the instructional material uninteresting and repetitious, leading to abandonment of effort (Sweller, 2012). Approaches under the LRI umbrella can be a means of addressing many of these factors that can underpin disengagement. Here the discussion centres on using different modalities, avoiding redundancy, increasing coherence, and providing appropriate instructional time.

Using different modalities

Learners can be cognitively exhausted through having to attend to information in a way that burdens a particular processor. For example, if too much information is presented visually (e.g. via text, call-out boxes, a diagram, a table etc.), the visual processor reaches capacity and so the learner must direct increasing energy to maintain it (Mayer & Moreno, 2010; Sweller, 2012). This excessive load risks the learner struggling to keep up and disengaging from the task (indeed, the split-attention effect may also excessively burden the learner in such ways). Rather than overloading the visual processor with, say, an image and text, some of the information can be offloaded onto the auditory processor as audible narrative (Mayer & Moreno, 2010; Sweller, 2012). Thus, where there is diverse material available, the educator might present different pieces of material in a different modality such as an image with a narrative that learners can listen to (referred to as the 'modality effect'; Ginns, 2005; Penney, 1989). Importantly, however, the information across modes must be different – simply repeating the same information in written and narrated form is inefficient and redundant. It is also apparent that any verbal or narrated information must be concise so as not to overload the auditory processor (Sweller, 2012).

In an adaptation of the modality effect, Moreno and Mayer (2010) identified the 'multimedia principle' as one with particular yield for novice learners. For learners with low prior knowledge, presenting material in dual modes (e.g. text and illustrations or narration and animation) can result in more meaningful learning. Because novices do not have prior knowledge to guide processing of new information, they may be assisted by additional modality to help structure information in working memory (Moreno & Mayer, 2010). On the other hand, experts tend not to need this additional modality.

Avoiding redundancy and increasing coherence

As noted above, it is important that material is not presented in a way that renders some of it redundant. Presenting the same information twice requires the learner to reconcile the two incoming sources of information and this adds to the processing required by working memory (Mayer & Moreno, 2010). It also runs the risk of rendering the instructional material uninteresting and repetitious, thereby increasing the risk of disengagement from the task.

For example, if there is a self-evident diagram presented, there is not a need for an explanatory text alongside it. In this case, the text is redundant and interferes with cognitive capacity (referred to as the 'redundancy effect'; Mayer & Moreno, 2010; Sweller, 2012). Thus, in a diagram on blood circulation in the heart, lungs and body, there can be arrows indicating the passage of blood – but not also statements below the diagram providing the same information about blood flow. The diagram is intelligible without the statements below it.

It is important to also distinguish between redundancy (which is ineffective) from rehearsal and repetition (which are effective). Redundancy involves presenting the same and unnecessary material simultaneously (which overloads working memory). Rehearsal involves presenting the same or similar material successively (which does not overload working memory; Sweller, 2012). Notwithstanding this, for some learners redundancy may be appropriate. For example, non-English speaking background students may benefit from the same material presented via text and narration. Obviously also, students with disabilities particular to the modality will also benefit from redundancy; hearing impaired students, for example, require that the same information is visually presented (Mayer & Moreno, 2010). In fact, more generally, Mayer and Johnson (2008) have also provided evidence that a small amount of redundancy in multimedia learning can support learning.

It is also important to organise material so that extraneous or overly elaborate material that may be tangential to essential learning is reduced or removed (Marzano, 2003; Purdie & Ellis, 2005). Presenting only the essential information to allow the full capacity of working memory to process it is referred to as the 'coherence principle' (Mayer & Moreno, 2010). Sometimes in efforts to make things interesting for learners, teachers may present sound effects or video break-outs. However, these added elements may be extraneous to the essential learning required and thus run the risk of burdening and exhausting the working memory that is required for the central learning (Mayer & Moreno, 2010). This is because information that is essential and should be presented explicitly to novices, becomes redundant for more knowledgeable learners – and thus reduced and then excluded. As relevant to motivation and engagement, emphasizing and presenting the essential information to learners identifies the key components of what is to be learned or accomplished and reduces the risk of rendering the instructional material uninteresting and repetitious, thereby reducing the risk of disengagement from the task.

A necessary first step in establishing coherence is for the teacher to clearly differentiate the content and skills students must master from the content and skills not so necessary to master. This involves establishing a hierarchy of essential content and skill (Marzano, 2003). Instructional approaches then revolve around this essential material, giving careful thought to what added elements may distract or burden the learner. Thus, there are clear cognitive yields through optimizing coherence.

Allowing appropriate instructional time

Estimates of how much instructional time students receive in class vary, with some as low as 21 per cent of class time and some as high as 69 per cent (Marzano, 2003 for a review). Using the lower bound, approximately 1–2 hours is devoted to instruction each day. Using the upper estimate, students receive approximately 3–4 hours instruction per day. This is a substantial difference in instructional time and, according to Marzano (2003) plays a major role in whether students get close to covering the full standards-driven curriculum. To the extent that some students do not cover the curriculum, their relative performance is likely to decline and this elevates the risk of disengagement (Covington, 2000; Finn, 1989).

LRI recognises there is a need for sufficient instructional time in a given task, unit, or topic. Effective teachers tend to generate more instructional time that is spent providing additional explanations, assigning more examples, and checking for understanding more frequently and deeply (Evertson, Anderson, Anderson & Brophy, 1980). This also means sufficient time to develop fluency and automaticity before moving on to independent practice and guided discovery learning. In contrast, less effective teachers tend to have less instructional time, provide shorter presentations, explanations and examples, and have less time to develop fluency and automaticity before moving students on to independent practice (Rosenshine, 1986, 2009). A lack of appropriate instructional time and preparation increases the risk of disengagement from the task or unit.

There are two ways that instructional time can be increased. The first is in terms of how much instructional time occurs in a lesson and across the day. This requires the school leadership to closely consider how the school day is organised and the scheduling of lesson time and order. It also requires teachers to minimise disruptions within the lesson in order to optimise actual instructional time. The second is in terms of specific teacher-led instructional moments. For example, in determining appropriate teacher-led instructional time, it has been suggested that teachers present for about 8–10 minutes before any practice activity (Rosenshine, 1986, 2009). Others have suggested the age-to-minute rule: here, for example, a teacher would present for no more than 11 minutes for 11-year-olds or 15 minutes for 15-year-olds (Martin, 2010). There would then be an appropriately timed and guided application for students to complete, at which point they would return to the teacher for further instructional input.

Taken together, across lesson scheduling and specific teacher-led instructional moments, it is important that students have greater access to curriculum material, have more time to cover this material, and receive appropriate time and direction from the expert (the teacher) as they move from novice status to become more developed learners. This helps students keep up with curriculum demands and subject matter as it is taught, thereby reducing the potential for disengagement.

Synthesis and implementation of motivation, engagement, and LRI elements

The preceding discussion has been aimed at addressing motivation and engagement factors salient in the literature and identifying well recognised elements of LRI approaches that align with or are conducive to the development of these factors. This being the case, Table 2a, Table 2b, and Figure 4 now synthesise what was presented in Table 1 and the subsequent analysis of motivation, engagement, and LRI.

Although Table 2a, Table 2b, and Figure 4 are organised factor by factor and approach by approach, this organisation is not intended to be prescriptive; rather, it is indicative of what type of LRI approaches might be considered for different motivation and engagement dimensions. Thus, for example, some LRI elements identified as relevant to addressing uncertain control (e.g. showcasing and feedback/feedforward) may also be effective in promoting students' persistence and self-efficacy.

Also, the range of motivation and engagement factors and the range of LRI approaches in Table 2a, Table 2b, and Figure 4 are not intended to be exhaustive or definitive. Indeed, other motivation and engagement frameworks and operationalizations (e.g. via PALS by Midgley et al., 1997; the MSLQ by Pintrich et al., 1991; the SEI by Appleton et al., 2006; the ISM by McInerney et al., 2000) will emphasise some different factors. In addition, diverse branches of cognitive and instructional psychology (e.g. Adams & Engelmann, 1996; Mayer & Moreno, 2010; Sweller, 2012) will emphasise different aspects of instruction that require distinct approaches to accommodating working and long-term memory.

Table 2a: Potential integration of Adaptive Motivation and Engagement Wheel Factors with Indicative Load Reduction Instruction (LRI) elements.

Adaptive Motivation and Adaptive Engagement (and indicative LRI elements)
Self-efficacy ■ Pre-training ■ Segmenting information ■ Preliminary and spaced reviews ■ Modelling important processes
Valuing ■ Integrating ■ Organising information thematically ■ Personalising
Mastery orientation ■ Signalling ■ Independent practice ■ Deliberate practice ■ Guided discovery learning
Planning (and monitoring) and task management ■ Mental practice ■ Worked examples ■ Guided practice
Persistence ■ Checking for understanding ■ Providing templates ■ Prompting

Table 2b: Potential integration of Maladaptive Motivation and Engagement Wheel Factors with indicative Load Reduction Instruction (LRI) elements.

Maladaptive Motivation and Maladaptive Engagement (and indicative LRI elements)
Anxiety, failure avoidance, and self-handicapping ■ Reducing split-attention ■ Information integration sequencing
Uncertain control ■ Showcasing ■ Feedback and feedforward
Disengagement ■ Using different modalities ■ Avoiding redundancy and increasing coherence ■ Allowing appropriate instructional time

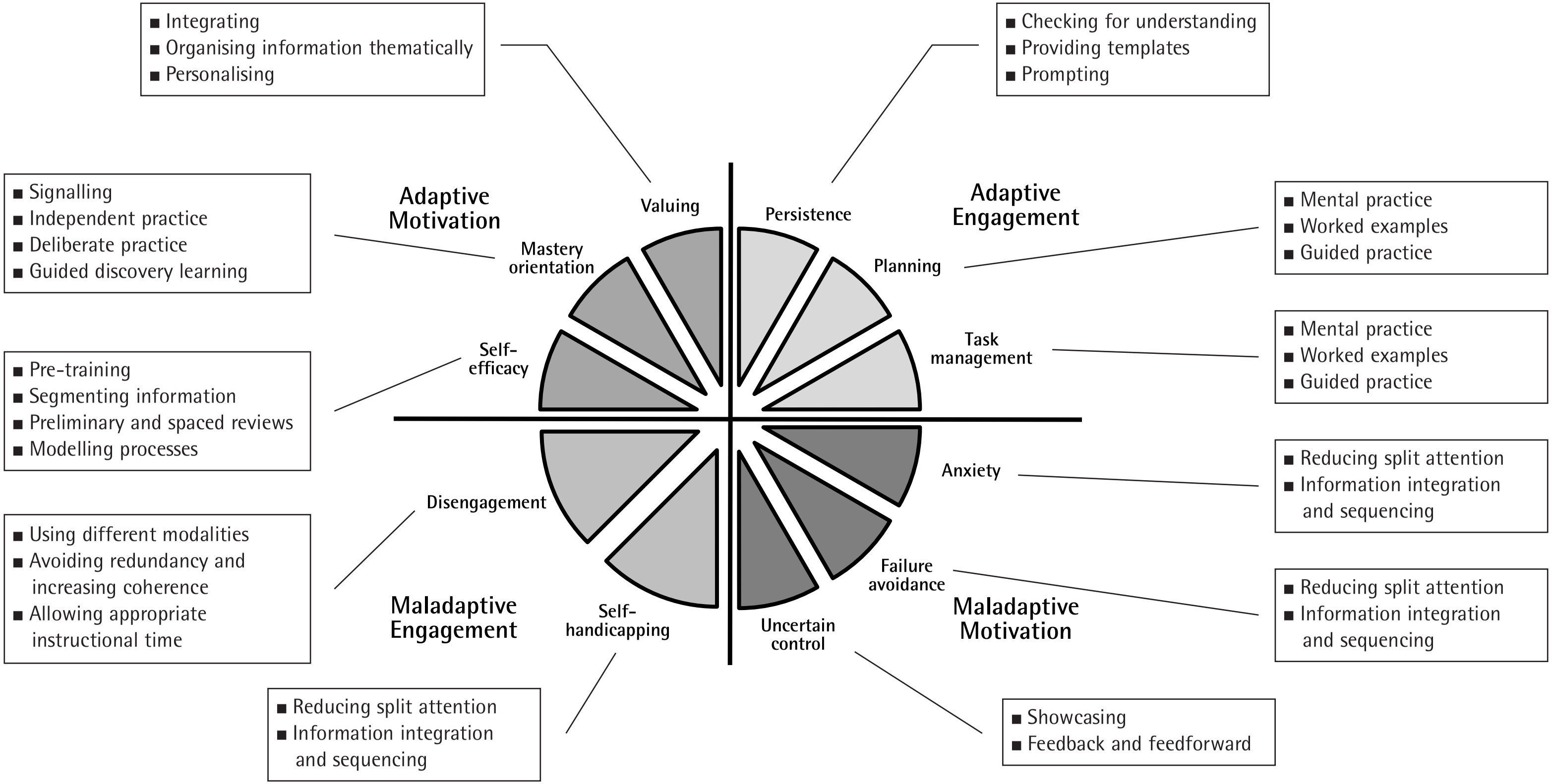

Figure 4: The Motivation and Engagement Wheel and potential integration with indicative Load Reduction Instruction (LRI) elements. Wheel is reproduced with permission from A.J. Martin and Lifelong Achievement Group (www.lifelongachievement.com)

Marzano (2003) also makes the important point that not all elements of an instructional taxonomy must be in the one lesson. Accordingly, it is not the intention that all LRI elements of Table 2a, Table 2b, and Figure 4 are implemented in the one lesson. Marzano suggests spreading a given instructional taxonomy or framework across a learning unit (not across one lesson). He suggests Bloom's (1956, 1976) learning units as one way to consider this approach. Based on Bloom's analysis, students encounter about 150 separate learning units in a year (about 7 hours each), which would translate into about 20–30 learning units per year in each major course. LRI taxonomies (e.g. Hunter, 1984; Marzano, 2003; Rosenshine, 1986, 2009) and integrative frameworks such as in Table 2a, Table 2b, and Figure 4 might be applied across one of these units. For example, in a given learning unit, some lessons (probably the early lessons) will emphasise pre-training, modelling, templates, worked examples and deliberate practice, while other lessons (probably the later lessons) will emphasise independent practice and guided discovery learning. Across the span of a whole learning unit in a given school subject, then, the teacher would look to implement a range of LRI elements to support broad and deep learning and a range of motivation and engagement factors.

This more distributed approach to LRI not only eliminates the pressure on the teacher to traverse all instructional elements in one lesson; it also provides further opportunity for the teacher to exert professional judgement on how to distribute the elements across a learning unit. Hence, counter to criticisms that LRI approaches reduce teachers to mechanical practices that constrain their professional input, this distributed approach to explicit taxonomies relies on the teacher to engage in professional decision-making as to what is implemented and when to implement it.

According to Rosenshine (1986, 2009), LRI-oriented frameworks can be readily adapted in the comprehensive classroom. For the novice learner, LRI might be applied in small steps with more frequent practice and more guidance and support from the teacher. For the expert learner, the presentation by the teacher can be longer, requiring less time in practice, less guidance from the teacher, less time spent checking for understanding, and more independent practice away from the teacher. But even for the expert learner, when the material is new, complex or hierarchically structured, there is a return to the more explicit LRI elements (e.g. pre-training, worked examples etc.) as new learning develops. Similarly, for less able students, Rosenshine (1986, 2009) suggests more review, less presentation, more guided practice, and more independent practice; for more able students, he suggests less review, more presentation, less guided practice, and less independent practice (see also Adams & Engelmann, 1996; DeRuvo, 2009; Hunter, 1984; Jones & Southern, 2003; Magliaro et al., 2005; Marzano, 2003; Stein, Silbert & Carnine, 1997).

PART 4. LOAD REDUCTION INSTRUCTION AND THE BROADER PROCESS OF LEARNING

This review is focused on instruction that reduces cognitive load on students. As detailed thus far, alongside quite explicit and directional approaches to instruction, there are discovery- and inquiry-oriented approaches that can also reduce the cognitive burden on students as they learn. Accordingly, guided practice, independent practice, and guided discovery learning were considered. These approaches are aimed at promoting learner independence while managing cognitive load appropriately, depending on the learner's novice/expert status. Although these approaches were addressed in Part 3, further consideration is given to them here with a view to better understanding their role in the broader process of learning and how they connect to LRI.

Guided discovery learning

Constructivist approaches to educational instruction give emphasis to learning environments that are rich in discovery and exploratory opportunities, prioritise students' own construction of meaning, and emphasise students' exploration and development of concepts for themselves (Pressley et al., 2003). The teacher's role tends to be more as facilitator, responsive to the student as he/she autonomously explores issues and solves problems (Ausubel, 1961; Bruner, 1961; Pressley et al., 2003). Indeed, Hattie (2009, 2012) has made the distinction between teacher as 'facilitator' (typically associated with constructivist approaches) and teacher as 'activator' (more aligned with explicit approaches).

Liem and Martin (2013; see also Pressley et al., 2003) emphasised the difference between pure discovery learning (predominantly unsupported and unassisted independent learning) and guided discovery learning (predominantly scaffolded, supported, monitored, assisted independent learning). They also note that the effects of guided discovery learning tend to be positive when learners are more skilled and knowledgeable (see also Kalyuga, Chandler, Tuovinen & Sweller, 2001). This is because guided discovery learning (implicitly or explicitly) recognises the limits of working memory, the need for accommodating working memory to build up long-term memory, and the substantial burden that pure discovery places on working memory (Kirshner et al., 2006; Paas et al., 2003; Sweller, 1988; Winne & Nesbit, 2010).

Indeed, naïve emphasis on pure discovery learning has led to some frustration among researchers: 'Like some zombie that keeps returning from its grave, pure discovery continues to have its advocates. However, anyone who takes an evidence-based approach to educational practice must ask the same question: Where is the evidence that it works? In spite of calls for free discovery in every decade, the supporting evidence is hard to find' (Mayer, 2004, p.17).

The role of guidance in the discovery process is particularly important because it is a further means by which the instructor can reduce the load on working memory (Martin, 2013, 2015). To the extent that this is the case, guided discovery learning is also a component of LRI. If too much of the process remains undefined and uncertain, too much of working memory must then be directed to potentially distracting and irrelevant processes that have the capacity to lead to misinterpretation, inaccurate conclusions, and inadequate skill development. If the instructor provides some guiding principles, prior information, signposts along the way, and scaffolds and assistance where needed, there is less burden on working memory. Thus, students are not denied the opportunity for discovery. Having developed the skills and subject-matter knowledge, these students are well positioned to engage in the discovery process. This inclusion of guided discovery learning under LRI is now discussed.

Load Reduction Instruction and guided discovery learning

In recent years there has been something of a tussle between predominantly constructivist (and post-modernist) approaches to instruction and more (post) positivist explicit and direct approaches to instruction. Interpretations of the former have led to student-centred learning, discovery and enquiry-based approaches, with the teacher seen more as a facilitator of learning. The latter (explicit) approach has been characterised as more teacher-centred, focused on explicit and structured instruction (including some deliberate practice and drill). For a recent review of this debate, see Tobias and Duffy (2009).

It is suggested that across the learning process, students' learning, motivation, and engagement are optimised by the teacher being both activator (through explicit approaches) and facilitator (through guided discovery approaches). To see the two roles (and instructional approaches) as incompatible and mutually exclusive is to set in place a false dichotomy. The two are compatible when: (a) we consider all the stages of learning involved when moving from novice to expert status and (b) guided discovery is a means to help manage the cognitive load on the learner in this process.

Having developed requisite knowledge and skills in long-term memory and having reduced the burden on working memory, learners can then be encouraged to apply the acquired knowledge and skill in independent, novel, and creative ways. Liem and Martin (2013) speculated that some of the low to moderate effect sizes associated with exploratory- and discovery-oriented learning (see their review and Hattie, 2009) may be a result of these learning practices being implemented too early in the learning process. Liem and Martin (2013) suggest that after sufficient direct input, guided practice and independent demonstration of learning, there is a critical role for guided discovery learning.

Thus, having moved beyond novice status, the learner now has the skills and requisite knowledge to engage in discovery-oriented approaches. Or, from a cognitive perspective, having acquired the skill and knowledge in long-term memory, and automated this skill and knowledge, there is no longer such a load on working memory. Learners' working memory can then be used to apply the knowledge and skill (that is long-term memory) in potentially new and self-determined ways. This notion lies at the heart of LRI.

Notably, research has confirmed that once learners become expert, they benefit more from problem solving approaches than from structured and explicit approaches to learning (e.g. Kalyuga, 2007; Kalyuga, Ayres, Chandler & Sweller, 2003; Kalyuga et al., 2001). If a student knows how to solve a problem, but still needs to practice solving such a problem to increase automation, it actually increases their working memory load to read through a worked example. In this case it is easier to solve the problem oneself through practice than read the worked example.

In addition, for experts and students who have mastered basic material, well-known limits on working memory fade faster than for novices and students who are not on top of the academic subject matter. For example, split attention effects disappear as expertise and mastery develop (referred to as the 'expert reversal effect'; Kalyuga et al., 2003). Because these students have acquired sufficient prior knowledge, fluency and/or automaticity, working memory is no longer placed under the typical strain experienced by the novice learner. In such cases, more complex material can be presented to the now expert learner. Similarly, expert learners do not benefit from presenting accompanying information in dual modalities – they are able to learn efficiently through one modality (e.g. just a diagram, or just a narration; Sweller, 2012).

A proposed process of explicit instruction and guided discovery learning

Taken together, there comes a point in the learning process and learner development when more complexity, novelty, and independence are not only desirable, but essential for further learning (Mayer, 2004). As summarised by Liem and Martin, 'it seems constructivist approaches are better assisted by direct and structured input from the teacher that systematically and unambiguously builds the knowledge and skills needed to subsequently engage in meaningful discovery, problem-based, and enquiry-based learning' (2013, p.368).

Indeed, this concept is not unfamiliar to cognitive load researchers who also recognise that there is a need to distinguish between the optimal learning conditions for the novice learner and the conditions that are appropriate for more developed learners in complex tasks. For example, Kalyuga and Singh (2015) outlined an approach that sought to smooth the typically rigid dichotomisation of explicit and discovery-oriented approaches. They suggested a more flexible approach based on differentiating specific goals of various learner activities in complex learning.

Figures 5a and 5b illustrate the proposed sequence of instruction that optimally draws on explicit through to guided inquiry, discovery, and exploratory learning. Importantly, the effectiveness of each mode relies heavily on recognition of the novice or expert status of the learner – and by implication, the status of their working memory, long-term memory, and their fluency and automaticity at each stage of the learning sequence.

Figure 5a is a general model of the LRI process and pertains to most learners (including those lower in ability). These learners require ample time, attention, and resources directed at the explicit instructional stage in order to lay a solid foundation for a guided exploratory and discovery phase.

Figure 5b is a high ability/expert model of the LRI process, where relatively less time, attention, and resources are directed at the explicit instructional stage as these learners progress more rapidly to a guided exploratory and discovery phase. Although the expert learner does not spend as much time as the novice in the explicit phase, time engaged in this phase is nonetheless necessary for the expert. Thus, for both groups, explicit instruction and guided discovery are considered necessary and desirable elements of the LRI process.

Student-centred instruction, student-centred exchange, and student-centred learning

This process may also be considered in terms of 'student-centred instruction', 'student-centred exchange', and 'student-centred learning'. Here the teacher is responsible for the organisation and presentation of instructional material with a clear and present focus on students' needs, including their cognitive needs (student-centred instruction). Guided practice, questioning, worked examples, and checking for understanding take place following the teacher's initial instruction (student-centred exchange). Then, with appropriate monitoring by the teacher (as needed and appropriate), the student is responsible for independent practice, checking and reviewing his/her own work, and engaging in further discovery or exploration (student-centred learning).

This aligns with the recent 'I do', 'We do', 'You do' approach to instruction (Archer & Hughes, 2011; see DeRuvo, 2009 for a summary in relation to at-risk students). The student-centred instruction corresponds to the 'I do' phase. The student-centred exchange corresponds to the 'We do' phase. The student-centred learning corresponds to the 'You do' phase.

McWilliam (2009) offers related insight into this process, identifying the teacher initially as the 'Sage on the stage'. Then in a more interactive and creative instructional phase, the teacher is the 'Meddler in the middle'. Learning then progresses to a point where the teacher is the 'Guide on the side'.

Of course, numerous pedagogical frameworks incorporate similar such processes, with 'gradual release of responsibility', 'balanced instruction', and 'enhanced discovery learning' models (e.g. Alfieri et al., 2011; Fisher & Frey, 2008; Marzano, 2011; Maynes et al., 2010; Pearson & Gallagher, 1983; Pressley & Allington, 2014) being among the more well recognised ones. The point is that at different stages of the educational process, teacher and student will play different roles, moving from (a) student instructional salience to (b) more distributed teacher-student interaction to (c) student learning salience. This pattern of instruction and learning plays out at each point students encounter new and/or challenging skill and content that are to be mastered. Notwithstanding these alignments with LRI, LRI is distinct in its development around cognitive load concepts and the core need to appropriately reduce or manage the cognitive burden on students to optimise their learning.

Figures 6a and 6b illustrate the process of student-centred instruction ('I do'; 'Sage on the stage'), student-centred exchange ('You do'; 'Meddler in the middle'), and student-centred learning ('We do'; 'Guide on the side'). Again, however, the effectiveness of each approach relies heavily on recognition of the novel or expert status of the learner – and by implication, the status of their working memory, long-term memory, and their fluency and automaticity at each stage of the learning sequence.

Figure 6a is a general model of the student-centred instruction, student-centred exchange, and student-centred learning process. It pertains to most learners (including those lower in ability). These learners require ample time, attention, and resources directed at the student-centred instruction ('I do') phase in order for the teacher to get a sense of their understanding and learning at the student-centred exchange ('We do') phase. Once satisfied with students' understanding and learning at

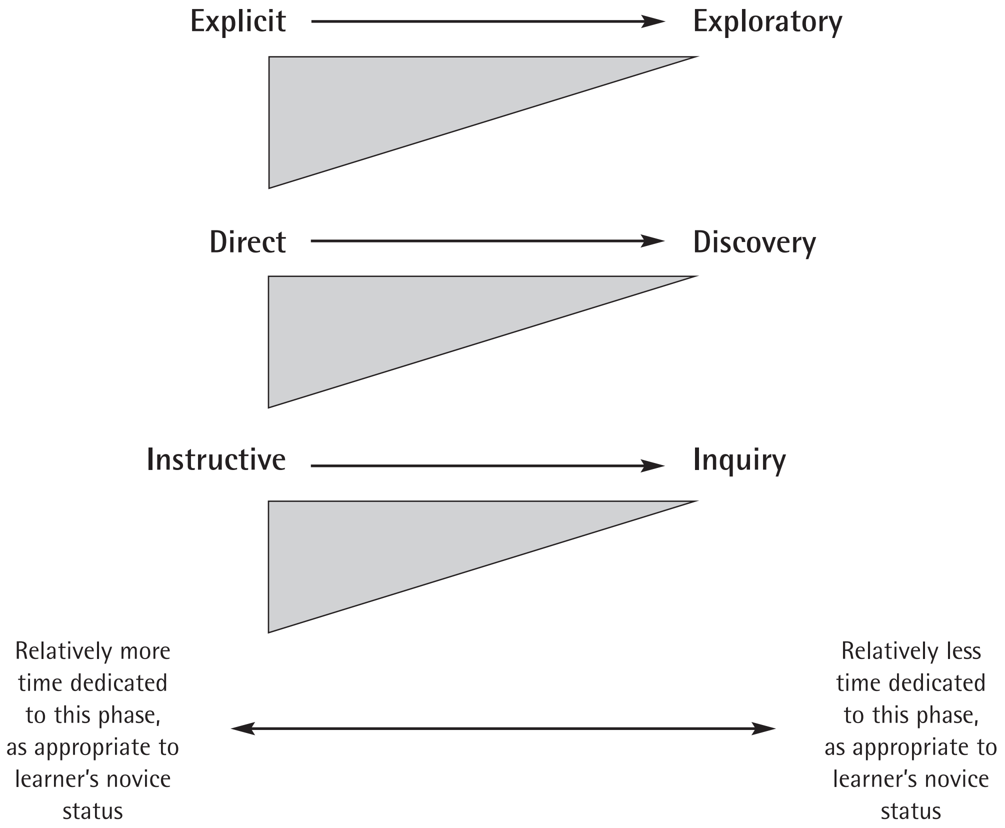

Figure 5a: General LRI process – From explicit to exploratory, direct to discovery, and instructive to inquiry.

this stage, there is an opportunity for student-centred learning ('You do').

Figure 6b is a high ability/expert model of the student-centred instruction, student-centred exchange, and student-centred learning process. Here, relatively less time, attention, and resources are directed at the student-centred instruction ('I do') phase as these learners progress more rapidly to student-centred exchange ('We do') and student-centred learning ('You do') phases. However, although the expert learner does not spend so much time in the 'I do' (student-centred instruction) phase, some time here is nonetheless necessary at key points of learning. Thus, for learners in the general and high ability/expert models, student-centred instruction, student-centred exchange, and student-centred learning are considered necessary and desirable elements of the learning process.

Importantly also, whereas most students in the classroom are across the subject matter towards the end of the 'We do' phase and are ready to move to the 'You do' phase of independent practice, it is also likely that there is a minority of students who require further LRI (Martin, 2015). The 'You do' phase – in which the bulk of the class is engaged in independent practice – is an ideal opportunity for these students to receive additional and one-on-one support from the teacher (or on occasion where appropriate, from expert peers). This 'I do', 'We do', 'You do' process is thus further effective because it also allows for individualised and one-on-one opportunities with at-risk students in the class.

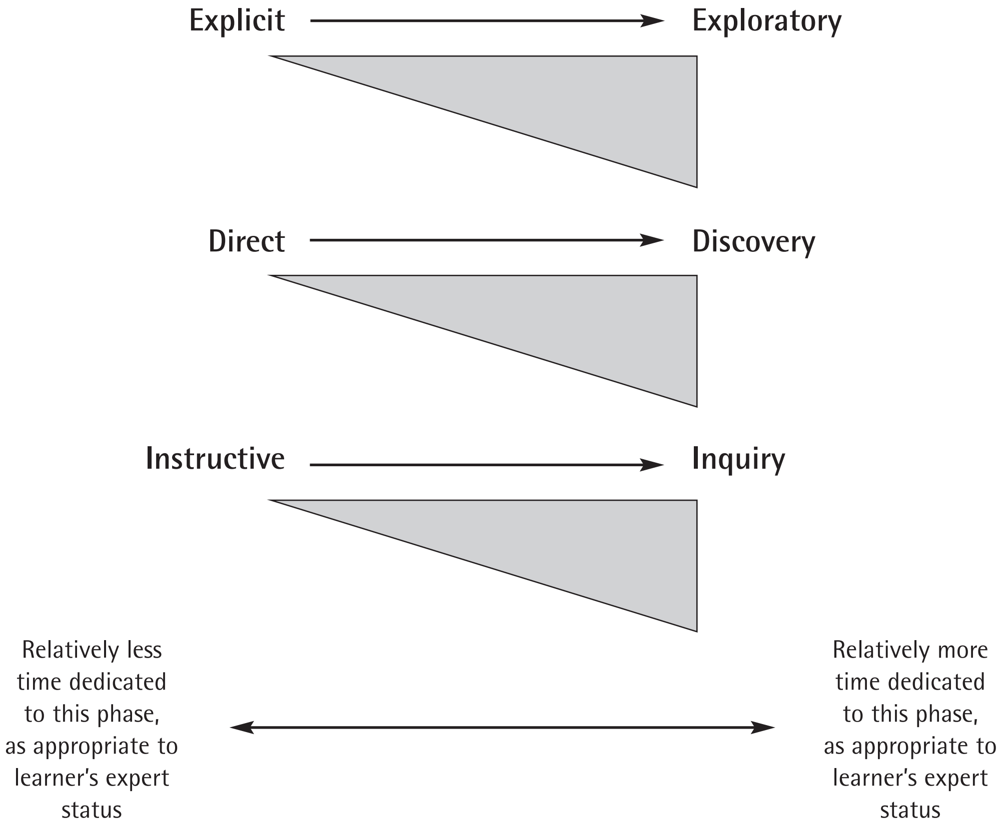

Figure 5b: High Ability/Expert LRI process – From explicit to exploratory, direct to discovery, and instructive to inquiry.

A cycle of Load Reduction Instruction and academic motivation and engagement

The present review has identified the potential for LRI approaches to foster and facilitate students' motivation and engagement. Of course, this connection is not static. Research shows there is a cycle that operates such that learning ('skill') fosters subsequent motivation and engagement ('will') (Covington, 1992, 1998; Marsh, 2007; Marsh & Martin, 2011; Martin, 2007, 2009, 2010; Pintrich, 2000). For example, self-efficacy is likely to be enhanced (or sustained) through the academic knowledge and skill that explicit instruction is shown to develop. Similarly, self-efficacy is associated with enhanced academic knowledge and academic skill (Schunk & Miller, 2002). Students who are high in self-efficacy generate alternative courses of action when at first they do not succeed, invest greater effort and persistence, and are better at adapting to problem situations (Bandura, 1997). Accordingly, they tend to achieve more highly (Schunk & Miller, 2002).

There is thus a reciprocal relationship between students' academic motivation and engagement on the one hand, and their academic learning and achievement on the other hand. These reciprocal effects have been demonstrated in various motivation literatures (e.g. see Marsh, 2007; Marsh & Martin, 2011 for summaries). Indeed, in the cognitive literature it is recognised that increases in motivation can increase the cognitive resources devoted to a task (Paas et al., 2003). To the extent that LRI is relevant to achievement (e.g. Cromley & Byrnes, 2009; Lee & Anderson, 2013; Liem & Martin, 2013; Mayer, 2004; Sweller, 2012) and to motivation and engagement (as proposed in this review), it is a further opportunity to promote the synergistic and mutually reinforcing relationship between achievement

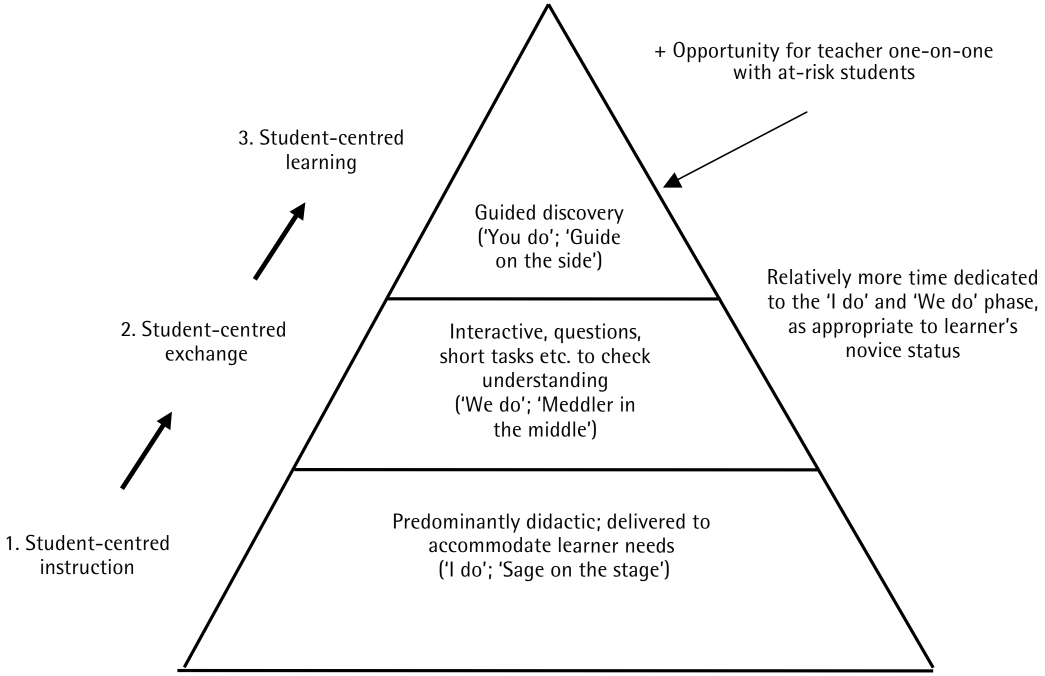

Figure 6a: General LRI Model: Student-centred instruction ('I do'; 'Sage on the stage'); Student-centred exchange ('You do'; 'Meddler in the middle'), and Student-centred learning ('We do'; 'Guide on the side').

and motivation and engagement.

The cycle might also be considered along the lines of an aptitude-treatment interaction (ATI). This concept holds that some instructional strategies are more (or less) effective for some individuals more than others, depending on their ability or other aptitude dimensions (Cronbach & Snow, 1977; Snow, 1991). When instruction is appropriately matched to the aptitudes of the learner, optimal learning takes place. One of the most common examples of an ATI involves instruction that differs in structure and completeness for high and low ability students. High ability students can learn with less structure and less complete instruction (though, even these students require structure and completeness in the early stages of learning; Adams & Engelmann, 1996; Rosenshine, 1986, 2008, 2009), whereas lower ability students have a greater need to learn under more highly structured instruction with well-defined sequences and components (Snow, 1991). Motivation and engagement might be considered another lens through which to consider ATIs with respect to LRI. LRI (the treatment) may be an effective means of boosting academic outcomes for students low in motivation and engagement (the aptitude). Thus, akin to students low in ability, students low in motivation and engagement may benefit from some key LRI elements. For example, along the lines of Table 2a, students low in self-efficacy may benefit from an emphasis on pre-training, segmented information, preliminary and spaced reviews, and modelling by the teacher. Following from this, enhanced outcomes may reflect optimised conditions that enable the student to move from novice to developed learner and thus benefit from the full scope of the learning and instructional process: from explicit instruction to guided discovery learning (see Figures 5 and 6).

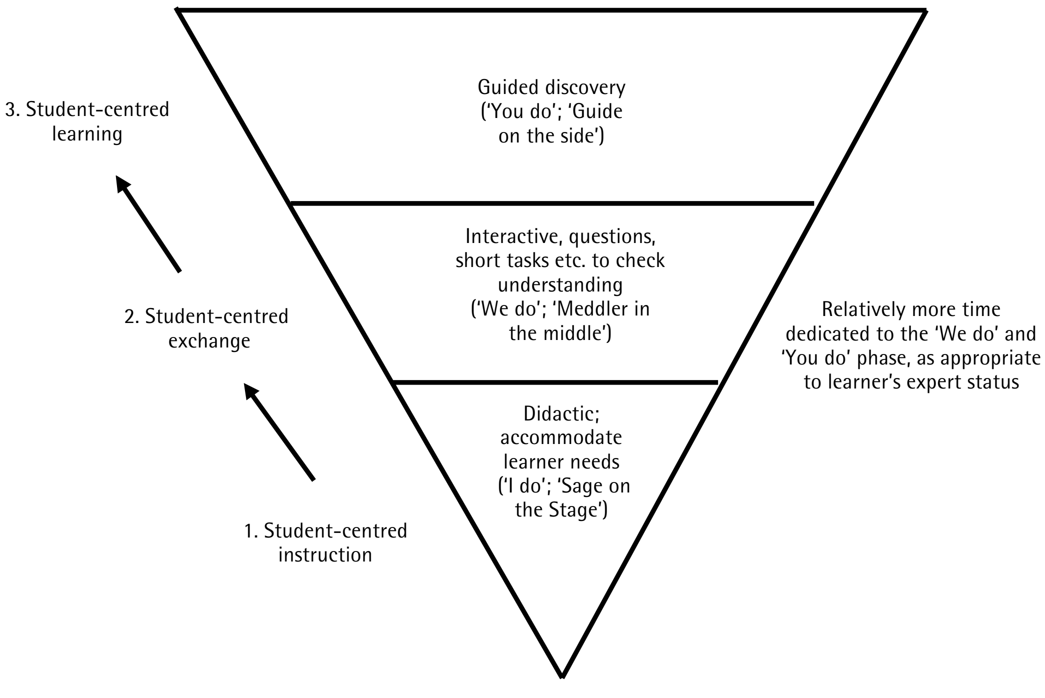

Figure 6b: High Ability/Expert LRI Model: Student-centred instruction ('I do'; 'Sage on the stage'); Student-centred exchange ('You do'; 'Meddler in the middle'), and student-centred learning ('We do'; 'Guide on the side')

PART 5: OPPORTUNITIES FOR FUTURE RESEARCH

This review has brought together two major literatures around cognitive psychology and educational psychology. Theory and research with regards to both have led to articulation of a proposed nexus between Load Reduction Instruction (LRI) and students' motivation and engagement. As relatively little direct and formal consideration has been given to this nexus, many of the arguments and contentions put forward require direct and formal empirical consideration. There are thus many opportunities for further research as we seek to gain a more complete understanding of how LRI and students' motivation and engagement connect.

As noted in the review, some LRI research has incorporated motivation and engagement factors and considerations and some motivation and engagement research has incorporated LRI factors and considerations. However, relatively little research has examined the two directly, seeking to map well-established motivation and engagement factors and theories to well-established LRI principles.

Following from this, the linking of LRI strategies under distinct motivation and engagement factors (Table 2a, Table 2b, Figure 4) is indicative and suggestive, not prescriptive or definitive. An empirical question is thus to ascertain which specific LRI strategies might explain most variance in distinct motivation and engagement factors. Findings from these investigations will no doubt illuminate and qualify some of the links suggested herein. Findings would also provide a more specific and concrete basis for educational practice and intervention.

The motivation and engagement factors under focus in this discussion are also indicative, not prescriptive, definitive, or exhaustive. The Motivation and Engagement Wheel was deemed a useful lens through which to consider the present issues because it traverses (a) numerous salient and well-established motivation and engagement theories, (b) cognitive, affective, and behavioural factors, and (c) adaptive and maladaptive dimensions (Liem & Martin, 2012; Martin, 2007, 2009). It was thus an encompassing framework with which to consider LRI implications for students' motivation and engagement. Nevertheless, there are other frameworks and models that would be equally beneficial in considering, including multidimensional motivation and engagement frameworks reflected in the Patterns of Adaptive Learning Survey (PALS) by Midgley and colleagues (1997), the Motivated Strategies for Learning Questionnaire by Pintrich et al. (1991), the Student Engagement Instrument (SEI) by Appleton et al. (2006), and the Inventory of School Motivation (ISM) by McInerney et al. (2000). Thus, research going forward has a range of motivation and engagement frameworks from which to choose.

These motivation and engagement frameworks also typically employ instrumentation that meets recognised measurement standards in that their scales tend to be multi-item, reliable, and validated against relevant external correlates. It is not uncommon for the cognitive psychology (including cognitive load) research to employ instrumentation that does not meet recognised measurement standards (e.g. single-item measures are frequently employed). Thus, when bringing LRI and student motivation and engagement together, researchers can benefit from the long-standing tradition of sound measurement that is predominant in the motivation and engagement literature.

Given much of this discussion has centred on the learning process and the progression from novice to developed learner (expert), it would be helpful to explore for any shifts in motivation and engagement as learning improves. This brings into consideration real-time motivation and engagement research through the LRI and learning process. Preliminary motivation and engagement research has been done based on the Motivation and Engagement Wheel factors (Martin, Papworth, Ginns, Malmberg, Collie & Calvo, 2015; see also Malmberg, Woolgar & Martin, 2013), but not in relation to LRI and the learning that occurs through a given task in real-time.

As noted at the outset of this review, school is academically demanding and becomes more so as students move from elementary to middle to high school (Martin, 2015). It has been shown that motivation and engagement decline over this time (Eccles et al., 1993; Eccles & Midgley, 1989; Martin, 2009). Thus, there are developmental issues as learners progress through the school years. We might therefore ask how LRI relates to motivation and engagement over this time. Following from answers to this question, what adjustments in LRI might need to occur from a developmental perspective?

From an evolutionary psychology perspective, there is emerging theory and research formally testing the implications of biologically primary and secondary knowledge for working memory and learning. It has been suggested that biologically primary knowledge (e.g. communicating, moving; Geary, 2007, 2008a, 2008b) is not such a burden on working memory (Paas & Sweller, 2012) and thus education that harnesses biologically primary knowledge may relieve some burden on working memory in order for learners to better acquire biologically secondary knowledge (e.g. mathematics, science, history). Some of the most recent work in this area has examined the role of movement (biologically primary knowledge) and embodied cognition in learning, finding for example, that tracing material can enhance the subsequent reproduction (i.e. learning) of that material (e.g. Hu, Ginns & Bobis, 2015; Macken & Ginns, 2014). Indeed, for students with known executive function impairments – such as those with ADHD – movement in the form of physical activity, and allowing some fidgeting or squirming while learning has been associated with enhanced working memory (e.g. Hartanto, Krafft, Iosif & Schweitzer, 2016; Sarver, Rapport, Kofler, Raiker & Friedman, 2015).

Given that biologically primary knowledge is seen as typically unconscious, effortless and rapid – and something that we evolve to acquire naturally (Geary, 2007, 2008a, 2008b; hence, low burden on working memory), we might speculate about its relationship to motivation. To the extent that biologically primary knowledge is unconscious and naturally acquired, is it also inherently and intrinsically motivating? To the extent that harnessing biologically primary knowledge reduces the burden on working memory and can enhance learning (Paas & Sweller, 2012), might it also have desirable motivational properties? Further, is it possible that incorporating biologically primary knowledge into learning processes and tasks has an additive effect on learning such that it frees up working memory for better learning and is also intrinsically motivating for the learner? Extending this speculation, to the extent that biologically primary knowledge may be intrinsically motivating, what are the implications of biologically secondary knowledge for motivation? As noted earlier, there is a known decline in motivation and engagement as students move from elementary to high school (e.g. Eccles et al., 1993; Eccles & Midgley, 1989; Martin, 2009) and this may in part be attributed to the greater emphasis on biologically secondary knowledge (e.g. mathematics, science, history etc.) in high school. Research into these ideas would be illuminating.

Whereas most LRI-related research has focused on the role of LRI in promoting learning and achievement, the focus of this review has been on LRI as relevant to students' motivation and engagement. It would be useful to consider the relative salience of LRI and motivation and engagement in promoting achievement. Indeed, it would also be useful to understand the extent to which the two may work together to produce more optimal learning and achievement outcomes.

As suggested at numerous points through the discussion, implications of cognitive load for academically at-risk learners can be significant. As Martin (2013, 2015) has indicated, there is a need for more motivation and engagement research among academically at-risk learners. Given the pertinence of LRI to at-risk learners (e.g. McMullen & Madelaine, 2014; Rupley et al., 2009; Swanson & Sachse-Lee, 2000), a suggested program of motivation and engagement research among these learners might also incorporate LRI considerations and what LRI buys such students with regards to motivation and engagement.

This review has also emphasised the importance of appropriately adjusting LRI to the development and expertise of the learner. Just as LRI researchers have identified boundary conditions for various LRI practices and learning outcomes (e.g. via the expert-reversal effect or the redundancy effect; Kalyuga & Singh, 2015; Mayer & Moreno, 2010; Sweller, 2012) so too might we identify boundary conditions for various LRI practices with regards to motivation and engagement outcomes. There is work suggestive of the importance of this research. For example, sub-optimally low cognitive load conditions can lead to boredom (Jackson, Kleitman & Aidman, 2014). Further work is needed here.

There has been some emphasis on the need to appropriately balance 'student-centred instruction' ('I do') with 'student-centred exchange' ('We do') and 'student-centred learning' ('You do') through the instructional process. There is a need to understand boundary conditions here as well. For example, what are the motivation and engagement implications for too little or too much time and attention to any one of these? Conceivably, too much 'student-centred instruction' ('I do') may lead to boredom and possible disengagement, while movement into 'student-centred learning' ('You do') when students are not quite ready may lead to anxiety. Figures 5 and 6 sought to accommodate this through representing the learning process in 'general' and 'high ability/expert' models – but it remains an empirical question as to the appropriate time, attention, and resources directed to each phase of the learning process for different learners.

This review has also emphasised guided discovery learning as a potential means to appropriately manage the cognitive burden on students in the learning process. It was also noted that pure discovery learning is relatively less likely to lead to formal achievement and learning gains (Kirschner et al., 2006; Mayer, 2004). This is because pure discovery learning (that is unsupported, unassisted, and unguided) increases cognitive load on the learner, impeding his/her learning. Notwithstanding this, although pure discovery may not be the optimal means to formal achievement-related ends, it has been considered as a desirable end in itself and something worthwhile for students to experience at appropriate points in the learning process (Bruner, 1961). Hence, this review does not discount the possibility that pure discovery learning may have motivation and engagement yields that are not so dependent on the need to reduce cognitive load and working memory demands. Future research might seek to juxtapose different levels of (un) supported discovery learning and their links to multidimensional motivation and engagement.

There is also the issue of what constitutes optimal guidance – as relevant to learner motivation and engagement – in guided discovery (and similar) phases. Whilst it is easy to advise that guidance is important, inevitably there will be cognitive load factors to consider when deciding what, when, and how much guidance to provide – which will likely have motivation and engagement implications for learners. Thus, understanding the motivation and engagement implications for different levels of guidance is important.

Following from this, it is important to recognise a line of research suggesting that minimal guidance for novices can be effective for their learning. Research into 'productive failure' is one such channel of work. Productive failure involves the design of conditions for learners to persist in generating and exploring solution methods for solving novel, complex problems. The process can initially lead to failure but this failure is claimed to provide an inherent efficacy that is important for learning – provided it is followed by an appropriate form of instructional intervention that assists subsequent solutions and methods (e.g. Kapur, 2008). To the extent that this is the case, productive failure research might provide direction for tasks or activities where minimal guidance for novices is desirable. Thus, the present review emphasises the importance of clear guidance and structure for novices in most learning conditions; however, on occasions where relatively little guidance for novices is intended, productive failure research might be helpful to set the conditions that optimise learning in these minimally guided situations.

The discussion also identified potential aptitude-treatment interactions (ATIs) that may occur in the learning process, with high ability students able to learn with less structure while lower ability students have a greater need to learn under structured instruction (Snow, 1991). It was suggested that motivation and engagement may be another lens through which to consider ATIs with respect to LRI. To what extent might LRI (the treatment) be a means of boosting academic outcomes for students low in motivation and engagement (the aptitude)?

Finally, LRI, as defined in this review, is broadly conceptualised. The review has not engaged in much differentiation between specific LRI approaches and the implications for students' motivation and engagement. There is scope for research seeking to distinguish motivation and engagement effects as a function of, for example, direct and explicit instructional approaches. Both approaches are grouped under the LRI umbrella but are distinct in important ways (e.g. see Adams & Engelmann, 1996; Kirschner et al., 2006; Liem & Martin, 2013; Rosenshine, 1986, 2008, 2009); what implications do these distinctions hold for motivation and engagement?

CONCLUSION

The bulk of research into instructional techniques that directly or indirectly reduce cognitive load (i.e. Load Reduction Instruction; LRI) has focused on academic learning and achievement. Findings support the role of LRI in students' learning and achievement gains. Less attention has been given to the role of LRI in promoting students' motivation and engagement. The present review has harnessed motivation and engagement as a lens through which to consider LRI. It has examined key dimensions of motivation and engagement and explored the extent to which specific approaches and strategies under LRI address them. It thus complements the large body of work into LRI and its achievement yields with closer consideration of its yields for students' motivation and engagement. The review has also considered the learning process more broadly and highlighted the role of guided discovery approaches in the learning sequence to appropriately manage cognitive load and generate greater autonomy and independent learning. Thus, it is emphasised that LRI encompasses both explicit instructional approaches and guided discovery-oriented learning – and that this has significant implications for students' academic motivation and engagement. Taken together, educators would do well to recognise the motivating and engaging properties of clear, structured and well guided instruction, and the role this plays in students' learning and achievement.

References

Abramson, L.Y., Seligman, M.E.P. & Teasdale, J. (1978). Learned helplessness in humans: Critique and reformulation. *Journal of Abnormal Psychology, 87,* 49–74. doi.org/10.1037/0021-843X.87.1.49

Adams, G. & Engelmann, S. (1996). *Research on Direct Instruction: 25 years beyond DISTAR.* Seattle, WA: Educational Achievement Systems.

Ainley, M.D. (2012). Students' interest and engagement in classroom activities. In Christenson L, Reschly L & Wylie (eds). *Handbook of research on student engagement.* New York: Springer.

Alfieri, L., Brooks, P.J., Aldrich, N.J. & Tenenbaum, H.R. (2011). Does discovery-based instruction enhance learning? *Journal of Educational Psychology, 103,* 1–18. doi.org/10.1037/a0021017

Algiraigri, A.H. (2014). Ten tips for receiving feedback effectively in clinical practice. *Medical Education Online, 19.* doi.org/10.3402/meo.v19.25141

Anderman, E.M. (2013). Middle school transitions. In J. Hattie & E.M. Anderman (Eds). *International guide to student achievement.* Routledge: New York.

Anderman, E.M. & Mueller, C.E. (2010). Middle school transitions and adolescent development. In J.L. Meece & J.S. Eccles (Eds). *Handbook of research on schools, schooling, and human development.* Routledge: New York.

Anderman, E.M. & Patrick, H. (2012). Achievement goal theory, conceptualization of ability/intelligence, and classroom climate. In S. L. Christenson, A.L. Reschly & C. Wylie (Eds.). *Handbook of research on student engagement* (pp.173–192). New York, NY: Springer. doi.org/10.1007/978-1-4614-2018-7_8

Anderman, E.M. & Wolters C. (2006). Goals, values, and affects: Influences on student motivation. In P. Alexander & P. Winne. (Eds). *Handbook of educational psychology.* New York: Simon & Schuster/Macmillan.

Appleton, J.J., Christenson, S.L., Kim, D. & Reschly, A.L. (2006). Measuring cognitive and psychological engagement: Validation of the Student Engagement Instrument. *Journal of School Psychology, 44,* 427–445. doi.org/10.1016/j.jsp.2006.04.002

Archer, A.L. & Hughes, C.A. (2011). *Explicit instruction: Effective and efficient teaching.* Guilford Press.

Ashcraft, M.H. & Kirk, E.P. (2001). The relationships among working memory, math anxiety, and *performance. Journal of Experimental Psychology: General, 130,* 224–237. doi.org/10.1037/0096-3445.130.2.224

Ashcraft, M.H. & Krause, J.A. (2007). Working memory, math performance, and math anxiety. *Psychonomic Bulletin and Review, 14,* 243–248. doi.org/10.3758/BF03194059

Atkinson, R.K., Derry, S.J., Renkl, A. & Wortham, D. (2000). Learning from examples: Instructional principles from the worked examples research. *Review of Educational Research, 70,* 181–214 doi.org/10.3102/00346543070002181

Ausubel, D.P. (1961). Learning by discovery: Rationale and mystique. *Bulletin of the National Association of Secondary School Principals, 45,* 18–58. doi.org/10.1177/019263656104526904

Baddeley, A. (1994). The magical number seven: Still magic after all these years? *Psychological Review, 101,* 353–356. doi.org/10.1037/0033-295X.101.2.353

Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: Freeman & Co.

Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual Review of Psychology, 52,* 1–26. doi.org/10.1146/annurev.psych.52.1.1

Basso, D. & Belardinelli, M.O. (2006). The role of the feedforward paradigm in cognitive psychology. *Cognitive Processing, 7,* 73–88. doi.org/10.1007/s10339-006-0034-1

Baumeister, R.F. & Scher, S.J. (1988). Self-defeating behavior patterns among normal individuals: Review and analysis of common self-destructive tendencies. *Psychological Bulletin, 104,* 3–22. doi.org/10.1037/0033-2909.104.1.3

Beck, A.T. (1976). *Cognitive therapy and the emotional disorders.* New York: New American Library.

Beck, A.T. (1995). *Cognitive therapy: Basics and beyond.* New York: Guilford.

Bessellieu, F.B., Kozloff, M.A. & Rice, J.S. (2001). Teachers' perceptions of direct instruction teaching. *Direct Instruction News, 1,* 14–17

Biggs, J.B. & Telfer, R. (1987). *The process of learning.* (2nd ed.) Burwood: Prentice-Hall.

Bjork, R.A. (1994). Memory and metamemory considerations in the training of human beings. In J. Metcalfe & A.P. Shimamura (Eds). *Metacognition: Knowing about knowing.* (pp.185–205). Cambridge, MA: The MIT Press.

Bjork, R.A. & Allen, T.W. (1970). The spacing effect: Consolidation or differential encoding? *Journal of Verbal Learning and Verbal Behavior, 9,* 567–572. doi.org/10.1016/S0022-5371(70)80103-7

Black, P., Harrison, C. & Lee, C. (2004). *Working inside the black box: Assessment for learning in the classroom.* Granada Learning. doi.org/10.1177/003172170408600105

Black, P. & Wiliam, D. (2004). The formative purpose: Assessment must first promote learning. *Yearbook of the National Society for the Study of Education, 103,* 20–50. doi.org/10.1111/j.1744-7984.2004.tb00047.x

Bloom, B.S. (1956). *Taxonomy of educational objectives, Handbook 1: The Cognitive Domain.* New York: Longman.

Bloom, B.S. (1976). *Human characteristics and school learning.* New York: McGraw-Hill.

Bodkin-Andrews, G.H., Denson, N. & Bansel, P. (2013). Teacher racism, academic self-concept, and multiculturation: Investigating adaptive and maladaptive relations with academic disengagement and self-sabotage for Indigenous and Non-Indigenous Australian students. *Australian Psychologist, 48,* 226–237. doi.org/10.1111/j.1742-9544.2012.00069.x

Bong, M. (1996). Problems in academic motivation research and advantages and disadvantages of their solutions. *Contemporary Educational Psychology, 21,* 149–165. doi.org/10.1006/ceps.1996.0013

Booth, M.Z. & Gerard, J.M. (2014). Adolescents' stage-environment fit in middle and high school: The relationship between students' perceptions of their schools and themselves. *Youth and society, 46,* 735–755.

Borman, G.D., Hewes, G.M., Overman, L.T. & Brown, S. (2003). Comprehensive school reform and achievement: A meta-analysis. *Review of Educational Research, 73,* 125–230. doi.org/10.3102/00346543073002125

Bost, L.W. & Riccomini, P.J. (2006). Effective instruction: An inconspicuous strategy for dropout prevention. *Remedial and Special Education, 27,* 301–311. doi.org/10.1177/07419325060270050501

Bruner, J.S. (1961). The act of discovery. *Harvard Educational Review, 31,* 21–32.

Bugler, M., McGeown, S.P. & St Clair-Thompson, H. (2015). *Gender differences in adolescents' academic motivation and classroom behavior.* Educational Psychology, *35,* 541–556..

Cantwell, D.P. & Baker, L. (1991). Association between attention deficit hyperactivity disorder and learning disorder. *Journal of Learning Disabilities, 24,* 88–95. doi.org/10.1177/002221949102400205

Carlson, C.D. & Francis, D.J. (2003). Increasing the reading achievement of at-risk children through direct instruction: Evaluation of the Rodeo *Institute for Teacher Excellence (RITE). Journal of Education for Students Placed At Risk, 7,* 141–166. doi.org/10.1207/S15327671ESPR0702_3

Carmichael, P., Adkins, Gaal, I., Hutchins, P., Levey, F., McCormack, J., Oberklaid, F., Pearson, C. & Storm, V. (1997). *Attention deficit hyperactivity disorder.* National Health and Medical Research Council, Australia.

Cepeda, N.J., Pashler, H., Vul, E., Wixted, J.T. & Rohrer, D. (2006). Distributed practice in verbal recall tasks: A review and quantitative synthesis. *Psychological Bulletin, 132,* 354–380. doi.org/10.1037/0033-2909.132.3.354

Cleary, T.J. & Zimmerman, B.J. (2012). A cyclical self-regulatory account of student engagement: Theoretical foundations and applications. In S. Christenson, A.L. Reschly & Wylie, C. (Eds.), Handbook of research on student engagement (pp.237–258). Springer. doi.org/10.1007/978-1-4614-2018-7_11

Collie, R.J., Martin, A.J. & Scott-Curwood, J. (in press, accepted September 2015). Multidimensional motivation and engagement for writing: Construct validation with a sample of boys. *Educational Psychology, 36,* 1285–1302.

Collie, R.J., Shapka, J.D., Perry, N.E. & Martin, A.J. (2015). Self-determination theory and teachers: Examining well-being, motivation, job satisfaction, and organizational commitment. *Journal of Educational Psychology.* doi.org/10.1037/edu0000088

Connell, J.P. (1985). A new multidimensional measure of children's perceptions of control. *Child Development, 56,* 1018–1041. doi.org/10.2307/1130113

Cooper, G. & Sweller, J. (1987). Effects of schema acquisition and rule automation on mathematical problem-solving transfer. *Journal of Educational Psychology, 79,* 347–362. doi.org/10.1037/0022-0663.79.4.347

Cordova, D.I. & Lepper, M.R. (1996). Intrinsic motivation and the process of learning: Beneficial effects of contextualization, personalization, and choice. *Journal of Educational Psychology, 88,* 715–730. doi.org/10.1037/0022-0663.88.4.715

Covington, M.V. (1992). *Making the grade: A self-worth perspective on motivation and school reform.* Cambridge: Cambridge University Press doi.org/10.1017/CBO9781139173582

Covington, M.V. (1998). *The will to learn: A guide for motivating young people.* New York: Cambridge University Press.

Covington, M.V. (2000). Goal theory, motivation, and school achievement: An integrative review. *Annual Review of Psychology, 51,* 171–200. doi.org/10.1146/annurev.psych.51.1.171

Craven, R.G., Marsh, H.W. & Debus, R.L. (1991). Effects of internally focused feedback and attributional feedback on the enhancement of academic self-concept. *Journal of Educational Psychology, 83,* 17–26. doi.org/10.1037/0022-0663.83.1.17

Cromley, J.G. & Byrnes, J.P. (2012). Instruction and cognition. *Wiley Interdisciplinary Reviews: Cognitive Science, 3,* 545–553. doi.org/10.1002/wcs.1192

Cronbach, L.J. & Snow, R.E. (1977). *Aptitudes and instructional methods.* New York: Irvington.

De Koning, B.B., Tabbers, H.K., Rikers, R.M. & Paas, F. (2009). Towards a framework for attention cueing in instructional animations: Guidelines for research and design. *Educational Psychology Review, 21,* 113–140 doi.org/10.1007/s10648-009-9098-7

Deci, E.L. & Ryan, R.M. (2012). Motivation, personality, and development within embedded social contexts: An overview of self-determination theory. In R.M. Ryan (Ed.), *The Oxford handbook of human motivation* (pp.85–110). New York, NY: Oxford University Press. doi.org/10.1093/oxfordhb/9780195399820.013.0006

DeRuvo, S.L. (2009). *Strategies for teaching adolescents with ADHD: Effective classroom techniques across the content areas.* San Francisco: Jossey-Bass.

Dowrick, P.W., Kim-Rupnow, W.S. & Power, T.J. (2006). Video feedforward for reading. *Journal of Special Education, 39,* 194–207. doi.org/10.1177/00224669060390040101

Dowrick, P.W., Tallman, B.I. & Connor, M.E. (2005). Constructing better futures via video. *Journal of Prevention and Intervention in the Community, 29,* 131–144. doi.org/10.1300/J005v29n01_09

Eccles, J.S. & Midgley, C. (1989). Stage-environment fit: Developmentally appropriate classrooms for young adolescents. In C. Ames & R. Ames (Eds). *Research on motivation in education: Goals and cognitions* (Vol 3, pp.139–186). New York: Academic Press.

Eccles, J.S., Midgley, C., Wigfield, A., Buchanan, C. M., Reuman, D., Flanagan, C. & Mac Iver, D. (1993). Development during adolescence: The impact of stage-environment fit on young adolescents' experiences in schools and in families. *American Psychologist, 48,* 90–101. doi.org/10.1037/0003-066X.48.2.90

Eccles, J.S. & Roeser, R.W. (2009). Schools, academic motivation, and stage-environment fit. In R.M. Lerner & L. Steinber (Eds.) *Handbook of Adolescent Psychology (3rd ed.)*(pp.404–434). Hoboken, N.J.: John Wiley & Sons.

Edgar, S. (2015). Identifying the influence of gender on motivation and engagement levels in student physiotherapists. *Medical Teacher, 37,* 348–353. doi.org/10.3109/0142159X.2014.948829

Elliot, A.J. (2005). A conceptual history of the achievement goal construct. In A.J. Elliot & C.S. Dweck (Eds). *Handbook of competence and motivation* (pp.52–72). New York: Guildford.

Elliot, A.J., Murayama, K., Kobeisy, A. & Lichtendfeld, S. (2014). Potential-based achievement goals. *British Journal of Educational Psychology, 85,* 192–206. doi:10.1111/bjep.12051

Elliot, A.J., Murayama, K. & Pekrun, R. (2011). A 3×2 achievement goal model. *Journal of Educational Psychology, 103,* 632–648. doi:10.1037/a0023952

Ericsson, K.A. (2014). *The road to excellence: The acquisition of expert performance in the arts and sciences, sports, and games.* New York: Psychology Press.

Ericsson, K.A. & Pool, R. (2016). *Peak: Secrets from the new science of expertise.* New York: Harcourt.

Evertson, C., Anderson, C., Anderson, L. & Brophy, J. E. (1980). Relationship between classroom behaviors and student outcomes in junior high mathematics and English classes. American *Educational Research Journal, 17,* 43–60. doi.org/10.3102/00028312017001043

Ewing, B. (2011). Direct instruction in mathematics: Issues for schools with high Indigenous enrolments: A literature review. *Australian Journal of Teacher Education, 36,* 64–91. doi.org/10.14221/ajte.2011v36n5.5

Eysenck, M.W. & Calvo, M.G. (1992). Anxiety and performance: The processing efficiency theory. *Cognition and Emotion, 6,* 409–434. doi.org/10.1080/02699939208409696

Farkota, R. (2003). *The effects of a 15-minute direct instruction intervention in the regular mathematics class on students' mathematical self-efficacy and achievement.* Doctoral Dissertation. Monash University, Australia.

Finn, J.D. (1989). Withdrawing from school. *Review of Educational Research, 59,* 117–142. doi.org/10.3102/00346543059002117

Finn, J.D. & Zimmer, K. (2013. Student engagement: What is it? Why does it matter? In S. Christenson, Reschly & Wylie (Eds.). *Handbook of research on student engagement* (pp.97–131). New York: Springer.

Fisher, D. & Frey, N. (2008). *Better learning through structured teaching: A framework for the gradual release of responsibility.* Alexandria, VA: Association for Supervision and Curriculum Development.

Forness, S.R. (2001). Special education and related services: What have we learned from meta-analysis? *Exceptionality, 9,* 185–197. doi.org/10.1207/S15327035EX0904_3

Forness, S.R., Kavale, K.A., Blum, I.M. & Lloyd, J.W. *(1997). Mega-analysis of meta-analyses. Teaching Exceptional Children, 29,* 4–9.

Fraser, K., Huffman, J., Ma, I., Sobczak, M., McIlwrick, J., Wright, B. & McLaughlin, K. (2014). The emotional and cognitive impact of unexpected simulated patient death: A randomized controlled trial. *CHEST Journal, 145,* 958–963. doi.org/10.1378/chest.13-0987

Fredricks, J.A., Blumenfeld, P.C. & Paris, A.H. (2004). Student engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74,* 59–109.doi.org/10.3102/00346543074001059

Geary, D.C. (2007). Educating the evolved mind: Reflections and refinements. In J.S. Carlson & J.R. Levin (Eds). *Educating the evolved mind: Conceptual foundations for an evolutionary educational psychology* (pp.177–203). Charlotte, NC: Information Age Publishing.

Geary, D.C. (2008a). An evolutionarily informed education science. *Educational Psychologist, 43,* 179–195. doi.org/10.1080/00461520802392133

Geary, D.C. (2008b). Whither evolutionary educational psychology? *Educational Psychologist, 43,* 217–226. doi.org/10.1080/00461520802392240

Gersten, R., Chard, D., Jayanthi, M., Baker, S., Morphy, P. & Flojo, J. (2009). *A meta-analysis of mathematics instructional interventions for students with learning disabilities.* Los Alamitos, CA: Instructional Research Group.

Gillen-O'Neel, C. & Fuligni, A. (2013). A longitudinal study of school belonging and academic motivation across high school. *Child Development, 84,* 678–692.

Ginns, P. (2005). Meta-analysis of the modality effect. *Learning and Instruction, 15,* 313–331. doi.org/10.1016/j.learninstruc.2005.07.001

Ginns, P. (2006). Integrating information: A meta-analysis of the spatial contiguity and temporal contiguity effects. *Learning and Instruction, 16,* 511–525. doi.org/10.1016/j.learninstruc.2006.10.001

Ginns, P., Martin, A.J., Liem, G.A.D. & Papworth, B. (2014). Structural and concurrent validity of the International English Big-Five Mini-Markers in an adolescent sample: Exploring analytic approaches and implications for personality assessment. *Journal of Research in Personality, 53,* 182–192. doi.org/10.1016/j.jrp.2014.10.001

Ginns, P., Martin, A.J. & Marsh, H.W. (2013). Designing instructional in a conversational style: A meta-analysis. *Educational Psychology Review, 25,* 445–472. doi.org/10.1007/s10648-013-9228-0

Good, TL. & Grouws, D.A. (1979). The Missouri Mathematics Effectiveness Project. *Journal of Educational Psychology, 71,* 143–155. doi.org/10.1037/0022-0663.71.3.355

Graham, C. & Hill, M. (2003). *Negotiating the transition to secondary school.* Scottish Council for Research in Education. Edinburgh: Scotland.

Guthrie, J.T. & Davis, M.H. (2003). Motivating struggling readers in middle school through an engagement model of classroom practice. *Reading and Writing Quarterly, 19,* 59–85. doi.org/10.1080/10573560308203

Haas, M. (2005). Teaching methods for secondary algebra: A meta-analysis of findings. *NASSP Bulletin, 89,* 24–46. doi.org/10.1177/019263650508964204

Hallahan, D.P. (1989). Attention disorders: Specific learning disabilities. In T. Husen & Postlethwait (Eds.). *The international encyclopedia of education: Research and studies* (pp.98–99). New York, NY: Pergamon.

Hanewald, R. (2013). Transition between primary and secondary school: Why it is important and how it can be supported. *Australian Journal of Teacher Education, 38,* 62–74. doi.org/10.14221/ajte.2013v38n1.7

Hartanto, T.A., Krafft, C.E., Iosif, A.M. & Schweitzer, J.B. (2016). A trial-by-trial analysis reveals more intense physical activity is associated with better cognitive control performance in attention-deficit/hyperactivity disorder. *Child Neuropsychology, 22,* 618–26. doi.org/10.1080/09297049.2015.1044511

Hattie, J. (2009). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement.* London and New York: Routledge.

Hattie, J. (2012). *Visible learning for teachers.* London and New York: Routledge.

Hu, F.T., Ginns, P. & Bobis, J. (2015). Getting the point: tracing worked examples enhances learning. *Learning and Instruction, 35,* 85–93. doi.org/10.1016/j.learninstruc.2014.10.002

Hunter, M. (1984). Knowing, teaching and supervising. In P. Hosford (Ed). *Using what we know about teaching* (pp.169–192). Alexandria, VA: ASCD.

Jackson, S.A., Kleitman, S. & Aidman, E. (2014). Low cognitive load and reduced arousal impede practice effects on executive functioning, metacognitive confidence and decision making. *PloS One, 9,* e115689. doi.org/10.1371/journal.pone.0115689

Jitendra A.K., Edwards, L.L., Sacks, G. & Jacobson, L.A. (2004). What research says about vocabulary instruction for students with learning disabilities. *Exceptional Children, 70,* 299–322. doi.org/10.1177/001440290407000303

Kagan, D.M. (1990). Ways of evaluating teacher cognition: Inferences concerning the Goldilocks principle. *Review of Educational Research, 60,* 419–469.

Kalyuga, S. (2007). Expertise reversal effect and its implications for learner-tailored instruction. *Educational Psychology Review, 19,* 509–539. doi.org/10.1007/s10648-007-9054-3

Kalyuga, S. (2011). *Cognitive load theory: Implications for affective computing.* AAAI Publications, Twenty-Fourth International FLAIRS Conference, Florida, USA.

Kalyuga, S., Ayres, P., Chandler, P. & Sweller, J. (2003). The expertise reversal effect. *Educational Psychologist, 38,* 23–31. doi.org/10.1207/S15326985EP3801_4

Kalyuga, S., Chandler, P., Tuovinen, J. & Sweller, J. (2001). When problem solving is superior to studying worked examples. *Journal of Educational Psychology, 93,* 579–588. doi.org/10.1037/0022-0663.93.3.579

Kalyuga, S. & Singh, A-M. (2015). Rethinking the boundaries of cognitive load theory in complex learning. *Educational Psychology Review.* doi.org/10.1007/s10648-015-9352-0

Kamps, D., Abbott, M., Greenwood, C., Wills, H., Veerkamp, M. & Kaufman, J. (2008). Effects of small group reading instruction and curriculum differences for students most at risk in kindergarten: Two-year results for secondary- and tertiary-level interventions. *Journal of Learning Disabilities, 41,* 101–114. doi.org/10.1177/0022219407313412

Kapur, M. (2008). Productive failure. *Cognition and Instruction, 26,* 379–424. doi.org/10.1080/07370000802212669

Kinder, D. & Bursuck, W. (1992). The research for a unified social studies curriculum; Does history really repeat itself? In D. Carnine & E.J. Kameenui (Eds). *Higher order thinking: Designing curriculum for mainstream students* (pp.23–38). Austin, TX: Pro-ed.

Kirschner, P.A., Sweller, J. & Clark, R.E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41,* 75–86. doi.org/10.1207/s15326985ep4102_1

Klahr, D. & Nigam, M. (2004). The equivalence of learning paths in early science instruction effects of direct instruction and discovery learning. *Psychological Science, 15,* 661–667. doi.org/10.1111/j.0956-7976.2004.00737.x

Kroesbergen, E.H. & Van Luit, J.E.H. (2003). Mathematics interventions for children with special educational needs. *Remedial and Special Education, 24,* 97–114. doi.org/10.1177/07419325030240020501

Ku, H.Y. & Sullivan, H.J. (2002). Student performance and attitudes using personalized mathematics instruction. *Educational Technology Research and Development, 50,* 21–34. doi.org/10.1007/BF02504959

Kulik, J. & Kulik, C.L. (1979). College teaching. In P. Peterson & H. Walberg, (Eds.). *Research on teaching: Concepts, findings and implications* (pp.70–93). Berkeley, CA: McCutcheon.

Kvalsund, R. (2000). The transition from primary to secondary level in smaller and larger rural schools in Norway: Comparing differences in context and social meaning. *International Journal of Educational Research, 33,* 401–424. doi.org/10.1016/S0883-0355(00)00025-2

Lee, H.S. & Anderson, J.R. (2013). Student learning: What has instruction got to do with it? *Annual Review of Psychology, 64,* 445–469. doi.org/10.1146/annurev-psych-113011-143833

Liem, G.A. & Martin, A.J. (2012). The Motivation and Engagement Scale: Theoretical framework, psychometric properties, and applied yields. *Australian Psychologist, 47,* 3–13. doi.org/10.1111/j.1742-9544.2011.00049.x

Liem, G.A.D. & Martin, A.J. (2013). Direct instruction and academic achievement. In J. Hattie & E. Anderman (Eds.). *International guide to student achievement.* Oxford: Routledge.

Linnenbrink-Garcia, L., Tyson, D.F. & Patall, E.A. (2008). When are achievement goal orientations beneficial for academic achievement? A closer look at moderating factors. *International Review of Social Psychology, 21,* 19–70.

Locke, E.A. & Latham, G.P. (2002). Building practically useful theory of goal setting and task motivation. *American Psychologist, 57,* 705–717. doi.org/10.1037/0003-066X.57.9.705

Macken, L. & Ginns, P. (2014). Pointing and tracing gestures may enhance anatomy and physiology learning. *Medical Teacher, 36,* 596–601. doi.org/10.3109/0142159X.2014.899684

Maehr, M.L. & Zusho, A. (2009). Achievement goal theory: The past, present, and future. In K.R. Wentzel & A. Wigfield (Eds). *Handbook of motivation at school* (pp.77–104). New York: Routledge.

Magliaro, S.G., Lockee, B.B. & Burton, J.K. (2005). Direct instruction revisited: A key model for instructional technology. *Educational Technology Research and Development, 53,* 41–55. doi.org/10.1007/BF02504684

Malmberg, L-E., Woolgar, C. & Martin, A.J. (2013). Quality of the Learning Experience Questionnaire (LEQ) for Personal Digital Assistants (PDAs). *International Journal of Quantitative Research in Education, 1,* 275–296. doi.org/10.1504/IJQRE.2013.057689

Marsh, H.W. (2007). *Self-concept theory, measurement and research into practice: The role of self-concept in educational psychology.* Leicester, UK: British Psychological Society.

Marsh, H.W. & Martin, A.J. (2011). Academic self-concept and academic achievement: Relations and causal ordering. *British Journal of Educational Psychology, 81,* 59–77. doi.org/10.1348/000709910X503501

Martin, A.J. (2003). *How to motivate your child for school and beyond.* Sydney: Random House/Bantam.

Martin, A.J. (2005). *How to help your child fly through life: The 20 big issues.* Sydney: Random House/Bantam.

Martin, A.J. (2007). Examining a multidimensional model of student motivation and engagement using a construct validation approach. *British Journal of Educational Psychology, 77,* 413–440. doi.org/10.1348/000709906X118036

Martin, A.J. (2009). Motivation and engagement across the academic lifespan: A developmental construct validity study of elementary school, high school, and university/college students. *Educational and Psychological Measurement, 69,* 794–824. doi.org/10.1177/0013164409332214

Martin, A.J. (2010). *Building classroom success: Eliminating academic fear and failure.* New York: Continuum.

Martin, A.J. (2012a). Attention Deficit Hyperactivity Disorder (ADHD), perceived competence, and self-worth: Evidence and implications for students and practitioners. In D. Hollar (Ed.). *Handbook on children with special health care needs* (pp.47–72). New York: Springer. doi.org/10.1007/978-1-4614-2335-5_3

Martin, A.J. (2012b). Motivation and engagement: Conceptual, operational and empirical clarity. Section Commentary in S. Christenson, A. Reschly & C. Wylie (Eds.). *Handbook of research on student engagement.* New York: Springer. doi.org/10.1007/978-1-4614-2018-7_14

Martin, A.J. (2013). From will to skill: The psychology of motivation, instruction and learning in today's classroom. *InPsych – Bulletin of Australian Psychological Society, December,* 10–12.

Martin, A.J. (2015). Teaching academically at-risk students in middle school: The roles of explicit instruction and guided discovery learning. In S Groundwater-Smith & N. Mockler (Eds). *Big fish, little fish: Teaching and learning in the middle years.* Cambridge: Cambridge University Press.

Martin, A.J. (2016). The Motivation and Engagement Scale (16th Edition). Sydney, Australia: Lifelong Achievement Group. www.lifelongachievement.com

Martin, A.J., Anderson, J., Bobis, J., Way, J. & Vellar, R. (2012). Switching on and switching off in mathematics: An ecological study of future intent and disengagement amongst middle school students. *Journal of Educational Psychology, 104,* 1–18. doi.org/10.1037/a0025988

Martin, A.J. & Elliot, A.J. (2016). The role of personal best (PB) and dichotomous achievement goals in students' academic motivation and engagement: A longitudinal investigation. *Educational Psychology,36* 1285–1302.

Martin, A.J., Ginns, P. & Papworth, B. (2016). *Motivation and engagement: Same or different? Does it matter?* Submitted for publication.

Martin, A.J. & Hau, K.-T. (2010). Achievement motivation amongst Chinese and Australian school students: Assessing differences of kind and differences of degree. *International Journal of Testing, 10,* 274–294. doi.org/10.1080/15305058.2010.482220

Martin, A.J. & Liem, G.A. (2010). Academic Personal Bests (PBs), engagement, and achievement: A cross-lagged panel analysis. *Learning and Individual Differences, 20,* 265–270.

Martin, A.J. Marsh, H.W. & Debus, R.L. (2001a). A quadripolar need achievement representation of self-handicapping and defensive pessimism. *American Educational Research Journal, 38,* 583–610. doi.org/10.3102/00028312038003583

Martin, A.J. Marsh, H.W. & Debus, R.L. (2001b). Self-handicapping and defensive pessimism: Exploring a model of predictors and outcomes from a self-protection perspective. *Journal of Educational Psychology, 93,* 87–102. doi.org/10.1037/0022-0663.93.1.87

Martin, A.J. Marsh, H.W. & Debus, R.L. (2003). Self-handicapping and defensive pessimism: A model of self-protection from a longitudinal perspective. *Contemporary Educational Psychology, 28,* 1–36. doi.org/10.1016/S0361-476X(02)00008-5

Martin, A.J., Marsh, H.W., Williamson, A. & Debus, R.L. (2003). Self-handicapping, defensive pessimism, and goal orientation: A qualitative study of university students. *Journal of Educational Psychology, 95,* 617–628. doi.org/10.1037/0022-0663.95.3.617

Martin, A.J., Martin, T.G. & Evans, P. (2016). Motivation and engagement in Jamaica: Testing a multidimensional framework among students in an emerging regional context. *Journal of Psychoeducational Assessment.* doi.org/10.1177/0734282916674424

Martin, A.J., Papworth, B., Ginns, P. & Liem, G.A.D. (2014). Boarding school, motivation and engagement, and psychological well-being: A large-scale investigation. *American Educational Research Journal, 51,* 1007–1049. doi.org/10.3102/0002831214532164

Martin, A.J., Papworth, B., Ginns, P., Malmberg, L-E., Collie, R. & Calvo, R.A. (2015). Real-time motivation and engagement during a month at school: Every moment of every day for every student matters. *Learning and Individual Differences, 38,* 26–35. doi.org/10.1016/j.lindif.2015.01.014

Martin, A.J., Way, J., Bobis, J. & Anderson, J. (2015). Exploring the ups and downs of mathematics engagement in the middle years of school. *Journal of Early Adolescence, 35,* 199–244. doi.org/10.1177/0272431614529365

Martin, A.J., Yu, K. & Hau, K-T. (2014). Motivation and engagement in the 'Asian Century': A comparison of Chinese students in Australia, Hong Kong, and Mainland China. *Educational Psychology: An International Journal of Experimental Educational Psychology, 34,* 417–439. doi.org/10.1080/01443410.2013.814199

Martin, A.J., Yu, K., Papworth, B., Ginns, P. & Collie, R.J. (2015). Motivation and engagement in USA, Canada, United Kingdom, Australia, and China: Testing a multidimensional framework. *Journal of Psychoeducational Assessment, 33,* 103–114. doi.org/10.1177/0734282914546287

Marzano, R.J. (1998). *A theory-based meta-analysis of research on instruction.* McREL, Aurora, Colorado

Marzano, R.J. (2003). *What works in schools.* Alexandria, VA: ASCD.

Marzano, R.J. (2011). Art and science of teaching / The perils and promises of discovery learning. *Educational Leadership, 69,* 86–87.

Mastropieri, M.A., Scruggs, T.E., Bakken, J.P. & Whedon, C. (1996). Reading comprehension: A synthesis of research in learning disabilities. *Advances in Learning and Behavioral Disabilities, 10B,* 201–227.

Matlen, B.J. & Klahr, D. (2010, June). Sequential effects of high and low guidance on children's early science learning. In *Proceedings of the 9th International Conference of the Learning Sciences-Volume 1* (pp.1016–1023). International Society of the Learning Sciences.

Mayer, R.E. (2004). Should there be a three-strikes rule against pure discovery learning? The case for guided methods of instruction. *American Psychologist, 59,* 14–19. doi.org/10.1037/0003-066X.59.1.14

Mayer, R.E. & Johnson, C.I. (2008). Revising the redundancy principle in multimedia learning. *Journal of Educational Psychology, 100,* 380–386 doi.org/10.1037/0022-0663.100.2.380

Mayer, R.E. & Moreno, R. (2010). Techniques that reduce extraneous cognitive load and manage intrinsic cognitive load during multimedia learning. (pp.131–152). In J.L. Plass., R. Moreno. & R. Brunken (Eds). *Cognitive load theory.* Cambridge: Cambridge University Press.

Maynes, N., Julien-Schultz, L. & Dunn, C. (2010). Modeling and the Gradual Release of Responsibility: What Does It Look Like in the Classroom? *Brock Education Journal, 19,* 65–77.

McInerney, D.M. (2000). *Helping kids achieve their best.* Sydney: Allen and Unwin.

Mcinerney, V., Marsh, H. W. & Mcinerney, D. M. (1999). The designing of the computer anxiety and learning measure (CALM): Validation of scores on a multidimensional measure of anxiety and cognitions relating to adult learning of computing skills using structural equation modeling. *Educational and Psychological Measurement, 59,* 451–470. doi.org/10.1177/00131649921969974

McInerney, D.M., Yeung, A.S. & McInerney, V. (2000). Cross-cultural validation of the Inventory of School Motivation (ISM): Motivation orientations of Navajo and Anglo students. *Journal of Applied Measurement, 2,* 135–153.

McKinney, J.D., Montague, M. & Hocutt, A.M. (1993). Educational assessment of students with attention deficit disorder. *Exceptional Children, 60,* 125–131.

McMullen, F. & Madelaine, A. (2014) Why is there so much resistance to Direct Instruction? Australian *Journal of Learning Difficulties, 19,* 137–151 doi.org/10.1080/19404158.2014.962065

McWilliam, E.L. (2009) Teaching for creativity: From sage to guide to meddler. *Asia Pacific Journal of Education, 29,* 281–293. doi.org/10.1080/02188790903092787

Meichenbaum, D. (1974). *Cognitive behavior modification.* Morristown, NJ: General Learning Press.

Midgley, C., Arunkumar, R. & Urdan, T. C. (1996). 'If I don't do well tomorrow, there's a reason': Predictors of adolescents' use of academic self-handicapping strategies. *Journal of Educational Psychology, 88,* 423–434. doi.org/10.1037/0022-0663.88.3.423

Midgley, C., Maehr, M., Hicks, L., Roesser, R., Urdan, T., Anderman, E., Kaplan, A., Arunkumar. R. & Middleton, M. (1997). *Patterns of Adaptive Learning (PALS).* Ann Arbor, MI: University of Michigan.

Miller, R.B., Greene, B.A., Montalvo, G.P., Ravindran, B. & Nichols, J.D. (1996). Engagement in academic work: The role of learning goals, future consequences, pleasing others, and perceived ability. *Contemporary Educational Psychology, 21,* 388–422. doi.org/10.1006/ceps.1996.0028

Moreno, R. & Mayer, R.E. (2010). Techniques that increase generative processing in multimedia learning: Open questions for cognitive load research. (pp.153–177). In J.L. Plass., R. Moreno. & R. Brunken (Eds). *Cognitive load theory.* Cambridge: Cambridge University Press.

Murphy, P.K. & Alexander, P.A. (2000). A motivated exploration of motivation terminology. *Contemporary Educational Psychology, 25,* 3–53. doi.org/10.1006/ceps.1999.1019

Nagabhushan, P. (2012). Academic motivation and engagement: An examination of its factor structure in senior school years. *The European Journal of Behavioural and Social Sciences, 2,* 260–277. doi.org/10.15405/FutureAcademy/ejsbs(2301-2218).2012.2.11

Nandagopal, K. & Ericsson, K.A. (2012). Enhancing students' performance in traditional education: Implications from the expert performance approach and deliberate practice (pp.257-293). In K.R. Harris., S. Graham. & T. Urdan (Eds). *APA educational psychology handbook.* Washington: American Psychological Association. doi.org/10.1037/13273-010

Nuthall, G. (1999). The way students learn: Acquiring knowledge from an integrated science and social studies unit. *The Elementary School Journal, 99,* 303–341 doi.org/10.1086/461928

Paas, F., Renkl, A. & Sweller, J. (2003). Cognitive load theory and instructional design: Recent developments. *Educational Psychologist, 38,* 1–4. doi.org/10.1207/S15326985EP3801_1

Paas, F. & Sweller, J. (2012). An evolutionary upgrade of cognitive load theory: Using the human motor system and collaboration to support the learning of complex cognitive tasks. *Educational Psychology Review, 24,* 27–45. doi.org/10.1007/s10648-011-9179-2

Pearson, P.D. & Gallagher, M. (1983). The instruction of reading comprehension. Contemporary *Educational Psychology, 8,* 317–344. doi.org/10.1016/0361-476X(83)90019-X

Penney, C.G. (1989). Modality effects and the structure of short-term memory. *Memory and Cognition, 17,* 398–442. doi.org/10.3758/BF03202613

Pintrich, P.R. (2000). Educational psychology at the millennium: A look back and a look forward. *Educational Psychologist, 35,* 221–226. doi.org/10.1207/S15326985EP3504_01

Pintrich, P.R. (2003). A motivational science perspective on the role of student motivation in learning and teaching contexts. *Journal of Educational Psychology, 95,* 667–686. doi.org/10.1037/0022-0663.95.4.667

Pintrich, P.R. & DeGroot, E. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology, 82,* 33–40. doi.org/10.1037/0022-0663.82.1.33

Pintrich, P.R., Smith, D.A.F., Garcia, T. & McKeachie, W.J. (1991). *A manual for the use of the Motivated Strategies for Learning Questionnaire (MSLQ).* Ann Arbor, MI: National Center for Research to Improve Postsecondary Teaching and Learning.

Plenty, S. & Heubeck, B.G. (2011). Mathematics motivation and engagement: an independent evaluation of a complex model with Australian rural high school students. *Educational Research and Evaluation, 17,* 283–299. doi.org/10.1080/13803611.2011.622504

Plenty, S. & Heubeck, B.G. (2013). A multidimensional analysis of changes in mathematics motivation and engagement during high school. *Educational Psychology, 33,* 14–30. doi.org/10.1080/01443410.2012.740199

Pollock, E., Chandler, P. & Sweller, J. (2002). Assimilating complex information. *Learning and Instruction, 12,* 61–86. doi.org/10.1016/S0959-4752(01)00016-0

Pressley, M. & Allington, R.L. (2014). *Reading instruction that works: The case for balanced teaching.* New York, NY: Guilford Publications.

Pressley, M., Roehrig, A.D., Raphael, L., Dolezal, S., Bohn, C., Mohan, L., Wharton-McDonald, R., Bogner, K. & Hogan, K. (2003). Teaching processes in elementary and secondary education. In W.M. Reynolds & G.E. Miller (Eds). *Handbook of educational psychology.* New Jersey: John Wiley & Sons. doi.org/10.1002/0471264385.wei0708

Przychodzin-Havis, A. M., Marchand-Martella, N.E., Martella, R.C. & Azim, D. (2004). Direct Instruction mathematics programs: An overview and research summary. *Journal of Direct Instruction, 4,* 53–84.

Przychodzin-Havis, A.M., Marchand-Martella, N.E., Martella, R.C., Miller, D.A., Warner, L., Leonard, B. & Chapman, S. (2005). An analysis of corrective reading research. *Journal of Direct Instruction, 5,* 37–65.

Purdie, N. & Ellis, L. (2005). *A review of the empirical evidence identifying effective interventions and teaching practices for students with learning difficulties in Years 4, 5, and 6.* Melbourne: Australian Council for Educational Research.

Reeve, J. (2012). A self-determination theory perspective on student engagement. In S.L. Christenson, A.L. Reschly & C. Wylie (Eds.). *Handbook of research on student engagement* (pp.149–172). New York. NY: Springer. doi.org/10.1007/978-1-4614-2018-7_7

Reeve, J. (2015). A grand theory of motivation: Why not? *Motivation and Emotion, 40,* 31–35. doi.org/10.1007/s11031-015-9538-2

Reeve, J., Deci, E.L. & Ryan, R.M. (2004). Self-determination theory: A dialectical framework for understanding socio-cultural influences on student motivation. In D. M. McInerney & S. Van Etten (Eds.). *Big theories revisited* (pp.31–60). Greenwich, CT: Information Age Press.

Reeves, J. (2010). Teacher learning by script. *Language Teaching Research, 14,* 241–258. doi.org/10.1177/1362168810365252

Renkl, A. (2014). Toward an instructionally oriented theory of example-based learning. *Cognitive Science, 38,* 1–37. doi.org/10.1111/cogs.12086

Renkl, A. & Atkinson, R.K. (2010). Learning from worked-out examples and problem solving. (pp.91-108). In J.L. Plass., R. Moreno. & R. Brunken (Eds). *Cognitive load theory.* Cambridge: Cambridge University Press.

Reschly, A.L. & Christenson, S.L. (2012). Jingle, jangle, and conceptual haziness: Evolution and future directions of the engagement construct. In S. Christenson, A. Reschly & C. Wylie (Eds.). *Handbook of research on student engagement.* New York: Springer. doi.org/10.1007/978-1-4614-2018-7_1

Rhodewalt, F. & Davison, J. (1986). Self-handicapping and subsequent performance: Role of outcome valance and attributional certainty. *Basic and Applied Social Psychology, 7,* 307–322. doi.org/10.1207/s15324834basp0704_5

Robins, P. M. (1992). A comparison of behavioral and attentional functioning in children diagnosed as hyperactive or learning disabled. *Journal of Abnormal Child Psychology, 20,* 65–82. doi.org/10.1007/BF00927117

Rosenshine, B.V. (1986). Synthesis of research on explicit teaching. *Educational Leadership, 43,* 60-69.

Rosenshine, B.V. (1995). Advances in research on instruction. *The Journal of Educational Research, 88,* 262–268. doi.org/10.1080/00220671.1995.9941309

Rosenshine, B.V. (2008). *Five meanings of direct instruction.* Lincoln: IL: Center on Innovation and Improvement .

Rosenshine, B.V. (2009). The empirical support for direct instruction. In S. Tobias & T.M. Duffy (Eds). *Constructivist instruction: Success or failure?* New York: Routledge.

Rupley, W.H., Blair, T.R. & Nichols, W.D. (2009). Effective reading instruction for struggling readers: The role of direct/explicit teaching. *Reading and Writing Quarterly, 25,* 125–138. doi.org/10.1080/10573560802683523

Ryan, R.M. & Deci, E.L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55,* 68–78. doi.org/10.1037/0003-066X.55.1.68

Sarver, D.E., Rapport, M.D., Kofler, M.J., Raiker, J.S. & Friedman, L.M. (2015). Hyperactivity in attention-deficit/hyperactivity disorder (ADHD): Impairing deficit or compensatory behavior? *Journal of Abnormal Child Psychology, 43,* 1219–1232. doi.org/10.1007/s10802-015-0011-1

Schieffer, C., Marchand-Martella, N.E., Martella, R. C., Simonsen, F.L. & Waldron-Soler, K.M. (2002). An analysis of the Reading Mastery program: Effective components and research review. *Journal of Direct Instruction, 2,* 87–119.

Schunk, D.H. & Miller, S.D. (2002). Self-efficacy and adolescents' motivation. In F. Pajares & T. Urdan (Eds). *Academic motivation of adolescents.* Connecticut: Information Age Publishing.

Schunk, D.H. & Mullen, C.A. (2012). Self-efficacy as an engaged learner. In S. Christenson, A. Reschly & C. Wylie (Eds.). *Handbook of research on student engagement.* New York: Springer. doi.org/10.1007/978-1-4614-2018-7_10

Schunk, D.H., Pintrich, P.R. & Meece, J.L. (2008). *Motivation in education.* Upper Saddle River, NJ: Pearson Education.

Schute, V.J. (2008). Focus on formative feedback. *Review of Educational Research, 78,* 153–189. doi.org/10.3102/0034654307313795

Senko, C. & Miles, K. M. (2008). Pursuing their own learning agenda: How mastery-oriented students jeopardize their class performance. *Contemporary Educational Psychology, 33,* 561–583.

Sierens, E., Vansteenkiste, M., Goossens, L., Soenens, B. & Dochy, F. (2009). The synergistic relationship of perceived autonomy support and structure in the prediction of self-regulated learning. *British Journal of Educational Psychology, 79,* 57–68. doi.org/10.1348/000709908X304398

Sirin, S.R. (2005). Socioeconomic status and academic achievement: A meta-analytic review of research. *Review of Educational Research, 75,* 417–453. doi.org/10.3102/00346543075003417

Skinner, E. A. (1996). A guide to constructs of control. *Journal of Personality and Social Psychology, 71,* 549–570. doi.org/10.1037/0022-3514.71.3.549

Snow, R.E. (1991). Aptitude-treatment interaction as a framework for research on individual differences in psychotherapy. *Journal of Consulting and Clinical Psychology, 59,* 205–216. doi.org/10.1037/0022-006X.59.2.205

Stein, M., Carnine, D. & Dixon, R. (1998). Direct instruction: Integrating curriculum design and effective teaching practice. *Intervention in School and Clinic, 33,* 227–234. doi.org/10.1177/105345129803300405

Stein, M., Silbert, J. & Carnine, D. (1997). *Designing effective mathematics instruction: A direct instruction approach.* Prentice Hall: Upper Saddle river, NJ: Merrill/Prentice Hall.

Stockard, J. (2010). Promoting reading achievement and countering the "Fourth-Grade Slump": The impact of Direct Instruction on reading achievement in fifth grade. *Journal of Education for Students Placed at Risk, 15,* 218–240. doi.org/10.1080/10824669.2010.495687

Stockard, J. (2011). Increasing reading skills in rural areas: An analysis of three school districts. *Journal of Research in Rural Education, 26,* 1–19.

Strand-Cary, M. & Klahr, D. (2008). Developing elementary science skills: Instructional effectiveness and path independence. *Cognitive Development, 23,* 488–511. doi.org/10.1016/j.cogdev.2008.09.005

Swanson, H.L., Carson, C. & Sachse-Lee, C.M. (1996). A selective synthesis of intervention research for students with learning disabilities. *School Psychology Review, 25,* 370–391.

Swanson, H.L. & Hoskyn, M. (1998). A synthesis of experimental intervention literature for students with learning disabilities: A meta-analysis of treatment outcomes. *Review of Educational Research, 68,* 271–321. doi.org/10.3102/00346543068003277

Swanson, H.L. & Sachse-Lee, C. (2000). A meta-analysis of single-subject-design intervention research for students with LD. *Journal of Learning Disabilities, 33,* 114–136. doi.org/10.1177/002221940003300201

Sweller J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science, 12,* 257–85. doi.org/10.1207/s15516709cog1202_4

Sweller, J. (2003). Evolution of human cognitive architecture. In Ross, B. (ed.), *The psychology of learning and motivation, Vol. 43.* Academic Press, San Diego, pp.215–266. doi.org/10.1016/s0079-7421(03)01015-6

Sweller, J. (2004). Instructional design consequences of an analogy between evolution by natural selection and human cognitive architecture. *Instructional Science, 32,* 9–31. doi.org/10.1023/B:TRUC.0000021808.72598.4d

Sweller, J. (2012). Human cognitive architecture: Why some instructional procedures work and others do not (pp.295–325). In K.R. Harris., S. Graham. & T. Urdan (Eds). *APA educational psychology handbook.* Washington: American Psychological Association. doi.org/10.1037/13273-011

Sweller, J., Ayres, P. & Kalyuga, S. (2011). *Cognitive load theory.* New York: Springer. doi.org/10.1007/978-1-4419-8126-4

Sweller, J. & Cooper, G.A. (1985). The use of worked examples as a substitute for problem solving in learning algebra. *Cognition and Instruction, 2,* 59–89. doi.org/10.1207/s1532690xci0201_3

Tabassam, W. & Grainger, J. (2002). Self-concept, attributional style and self-efficacy beliefs of students with learning disabilities with and without Attention Deficit Hyperactivity Disorder. *Learning Disability Quarterly, 25,* 141–151. doi.org/10.2307/1511280

Tarver, S. (1998). Myths and truths about direct instruction. *Effective School Practices, 17,* 18–22.

Tarver, S. & Jung, J.S. (1995). A comparison of mathematics achievement and mathematics attitudes of first and second graders instructed with either a discovery-learning mathematics curriculum or a Direct Instruction curriculum. *Effective School Practices, 14,* 49–57.

Thompson, T. (1994). Self-worth protection: Review and implications for the classroom. *Educational Review, 46,* 259-274. doi.org/10.1080/0013191940460304

Tinker, S. & Elphinstone, B. (2014). Learning engagement: The importance of meaning, belonging and academic momentum. *The International Journal of the First Year in Higher Education, 5,* 93–105.

Tobias, S. (1982). When do instructional methods make a difference? *Educational Researcher, 11,* 4–10. doi.org/10.2307/1174134

Tobias, S. & Duffy, T.M. (Eds.). (2009). *Constructivist instruction: Success or failure?* New York, NY: Routledge.

Tomlinson, C.A. (2001). *How to differentiate instruction in mixed-ability classrooms.* Alexandria, VA: ASCD.

Van den Heuvel-Panhuizen, M. & Drijvers, P. (2014). Realistic Mathematics Education. In S. Lerman (Ed.), *Encyclopedia of mathematics education* (pp.521–525). Dordrecht, Heidelberg, New York, London: Springer doi.org/10.1007/978-94-007-4978-8_170

Van Gog, T., Ericsson, K.A., Rikers, R.M.J. . & Paas, F. (2005). Instructional design for advanced learners: Establishing connections between the theoretical frameworks of cognitive load and deliberate practice. *Educational Technology, Research and Development, 53,* 73–81. doi.org/10.1007/BF02504799

Van Keer, H. & Verhaeghe, J.P. (2005). Effects of explicit reading strategies instruction and peer tutoring on second and fifth graders' reading comprehension and self-efficacy perceptions. *The Journal of Experimental Education, 73,* 291–329. doi.org/10.3200/JEXE.73.4.291-329

Van Merriënboer, J.J. (1992). Training complex cognitive skills: A four-component instructional design model for technical training. *Educational Technology Research and Development, 40,* 23–43. doi.org/10.1007/BF02297047

Van Merriënboer, J.J. & Sweller, J. (2005). Cognitive load theory and complex learning: Recent developments and future directions. *Educational Psychology Review, 17,* 147–177. doi.org/10.1007/s10648-005-3951-0

Vitale, M.R. & Romance, N.R. (1992). Using videodisk instruction in an elementary science methods course: Remediating science knowledge deficiencies and facilitating science teaching attitudes. *Journal of Research in Science Teaching, 29,* 915–928. doi.org/10.1002/tea.3660290903

Voelkl, K.E. (2012). School identification. In S.L. Christenson, A.L. Reschly & C.Wylie (Eds.). *Handbook of research on student engagement* (pp.193–218). New York: Springer. doi.org/10.1007/978-1-4614-2018-7_9

Walkington, C.A. (2013). Using adaptive learning technologies to personalize instruction to student interests: The impact of relevant contexts on performance and learning outcomes. *Journal of Educational Psychology, 105,* 932–945. doi.org/10.1037/a0031882

Wang, M.T. & Eccles, J.S. (2012). Adolescent behavioral, emotional, and cognitive engagement trajectories in school and their differential relations to educational success. *Journal of Research on Adolescence, 22,* 31–39.

Weiner, B. (1985). An attributional theory of achievement motivation and emotion. *Psychological Review, 92,* 548–573. doi.org/10.1037/0033-295X.92.4.548

Weiner, B. (2010). The development of an attribution-based theory of motivation: A history of ideas. *Educational Psychologist, 45,* 38–36. doi.org/10.1080/00461520903433596

Wigfield, A. & Eccles, J.S. (2000). Expectancy-value theory of motivation. *Contemporary Educational* Psychology, 25, 68–81. doi.org/10.1006/ceps.1999.1015

Wigfield, A, Guthrie, J.T., Perencevich, K.C., Taboada, A., Klauda, S.L., McRae, A. & Barbosa, P. (2008). Role of reading engagement in mediating effects of reading comprehension instruction on reading outcomes. *Psychol Schs, 45:* 432–445. doi: 10.1002/pits.20307

Wigfield, A, Guthrie, J.T., Tonks, S. & Perencevich, K.C. (2004). Children's motivation for reading: Domain specificity and instructional influences. *The Journal of Educational Research, 97,* 299–310. doi.org/10.3200/JOER.97.6.299-310

Wigfield, A. & Tonks, S. (2002). Adolescents' expectancies for success and achievement task values during middle and high school years. In F. Pajares & T. Urdan (Eds). *Academic motivation of adolescents.* Connecticut: Information Age Publishing.

Wiliam, D. (2011). *Embedded formative assessment. Bloomington.* IN: Solution Tree Press.

Winne, P.H. & Nesbit, J.C. (2010). The psychology of academic achievement. *Annual Review of Psychology, 61,* 653–678. doi.org/10.1146/annurev.psych.093008.100348

Wood, D., Bruner, J.S. & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry, 17,* 89–100 doi.org/10.1111/j.1469-7610.1976.tb00381.x

Wurf, G. & Croft-Piggin, L. (2015). Predicting the academic achievement of first-year, pre-service teachers: the role of engagement, motivation, ATAR, and emotional intelligence. Asia-Pacific *Journal of Teacher Education, 43,* 75–91. doi.org/10.1080/1359866X.2014.932328

Yeung, A.S., Barker, K., Tracey, D. & Mooney, M. (2013). School-wide positive behavior for learning: Effects of dual focus on boys' and girls' behavior and motivation for learning. *International Journal of Educational Research, 62,* 1-10. doi.org/10.1016/j.ijer.2013.06.002

Yin, H. & Wang, W. (2015). Undergraduate students' motivation and engagement in China: An exploratory study. *Assessment & Evaluation in Higher Education, 41,* 601–621.

Yu, K. & Martin, A.J. (2014). Personal best (PB) and 'classic' achievement goals in the Chinese context: Their role in predicting academic motivation, engagement, and buoyancy. *Educational Psychology: An International Journal of Experimental Educational Psychology, 34,* 635–658. doi.org/10.1080/01443410.2014.895297

Zeedyk, M.S., Gallacher, J., Henderson, M., Hope, G., Husband, B. & Lindsay, K. (2003). Negotiating the transition from primary to secondary school perceptions of pupils, parents and teachers. *School Psychology International, 24,* 67–79. doi.org/10.1177/0143034303024001010

Zimmerman, B.J. (2002). Achieving self-regulation: The trial and triumph of adolescence. In F. *Pajares & T. Urdan (Eds). Academic motivation of adolescents.* Connecticut: Information Age Publishing.

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