Australian Education Research Organisation

How students learn best

An overview of the learning process and the most effective teaching practices

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The Australian Education Research Organisation (AERO) is Australia's national education evidence body, working to achieve excellence and equity in educational outcomes for all children and young people.

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Acknowledgement of Country

AERO acknowledges the Traditional Custodians of the lands, waterways, skies, islands and sea Country across Australia. We pay our deepest respects to First Nations cultures and Elders past and present. We endeavour to continually value and learn from First Nations knowledges and educational practices.

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Executive summary

Teaching practices that are aligned with how students learn improve educational outcomes for all students. Empirical evidence gained over recent decades has provided important new insights about the learning process common to students across learning contexts. These processes explain why some teaching practices are more effective than others.

In this paper, the Australian Education Research Organisation (AERO) provides an overview of evidence-based teaching practices found to enhance educational outcomes for all students. The paper connects the understanding of how students learn best with practical implications for teachers. AERO has also developed a model of learning and teaching that aligns effective and efficient teaching practices with how students learn at various phases of the learning process.

This paper and model of teaching and learning are relevant for teaching school-aged students across all Australian classrooms. They recognise that the mechanisms of learning are the same for all students. Some students experience persistent difficulties or differences in processing information that necessitate more frequent, intense and sustained scaffolding and support, but all students benefit from evidence-based practices that align with the processes of acquiring, retaining, retrieving and consolidating learning.

In this paper, we explore 4 key areas that shed light on the student learning process and how effective teaching aligns with these processes to maximise progress and outcomes.

1. Learning is a change in long-term memory

There are 2 types of memory that process information during learning: working memory and long-term memory. Working memory is the mental workspace that students use to actively engage with the facts, concepts and procedures they encounter, while long-term memory stores this knowledge for future use. As students learn, they identify relationships and connect knowledge in long-term memory to develop increasingly complex mental models. Students processing new information will learn most effectively when taught by someone with expert knowledge.

2. Students process limited amounts of new information

Working memory has a very limited capacity, so learning is maximised when the amount of new information students process at any one time does not overload it. Providing students with new information in manageable parts or steps, with guidance, feedback and opportunities to practise helps them to connect and retain it alongside related prior knowledge in long-term memory. Guidance, scaffolding and opportunities to practise also support retention of learning, particularly for those students with further limitations and differences in their capacity for processing information.

3. Students develop and demonstrate mastery

Developing mastery requires students to first store knowledge (including facts, concepts or procedures) in long-term memory and then recall and arrange it in meaningful ways. As these mental models grow, reflecting students' understanding, they learn about and begin to recognise the relationships between facts, concepts and procedures. With repeated and varied practise, students' ability to recall and apply their learning fluently, and to transfer their knowledge to new situations, increases. Once knowledge is consolidated in long-term memory, students can retrieve and combine it in varied ways to test possible solutions to unfamiliar problems and generate creative ideas. Students' capacity for critical thinking, creativity and problem-solving is greatly enhanced when they have relevant background knowledge consolidated in long-term memory to draw on.

4. Students are actively engaged when learning

Transferring information from working memory to long-term memory requires students' focused attention and active engagement in a supportive and responsive learning environment. Students are motivated to engage when they understand their effort leads to success, develop positive dispositions towards learning, and have positive relationships with teachers. The experience of success is motivating. Students who feel culturally safe, supported and have a positive sense of belonging within their learning community are also more actively engaged in their learning. Engagement and focus on learning are further increased when students understand the expected behaviours and routines of the learning environment, as well as the intended goals of their learning. The most effective teaching practices foster a supportive learning environment and enable students to focus their attention to successfully acquire the knowledge and skills they need to be successful in their learning.

Implications for teaching practice

The goal of education outlined in the 2019 Alice Springs (Mparntwe) Education Declaration (Australian Government Department of Education, Skills and Employment, 2019) is for all young Australians to become confident and creative individuals, successful lifelong learners, and active and informed members of the community. Teachers and school leaders, through the instructional approaches used in schools, make a dramatic difference to the skills, capacities and dispositions students gain through their education. Students develop positive dispositions and capacities for independent learning when they experience well-structured, sequenced and supportive approaches to acquiring new knowledge and skills, referred to as explicit teaching or explicit instruction. Explicit teaching is the most effective way of supporting students to achieve these goals. It equips students with a strong foundation of knowledge and skills and ensures they can recall and apply learning from memory in varied ways.

The Australian Curriculum defines the content considered important for all young Australians to learn. Ensuring that all students can acquire and retain this breadth of knowledge and skills requires explicit teaching from knowledgeable experts. This builds the foundations for students to engage in and benefit from more independent learning. Along with important functions that develop from early childhood, such as the capacity to direct attention, and equipped with consolidated knowledge and skills, students then have the essential ingredients to apply their imagination, to enquire and to generate new learning. This ensures they are better set up to create and contribute their own unique ideas with increasing confidence and independence.

There is an abundance of advice on effective teaching practices. Some advice has been learned and shared directly amongst educators, including highly experienced and expert teachers, and some indirectly through the collaborative efforts of teachers working with researchers. Empirical evidence gained over the past 20 to 30 years has provided new and important insights into the learning process that have only become possible with technological advances that have allowed us to explore the workings of the human mind and brain.

When teachers experience challenges in meeting the learning needs of all their students and seek out advice, it can be difficult to discern which approaches will be most relevant and impactful. AERO has explored the use of evidence-based practices in Australian schools and found a wide variation in their adoption. AERO believes that knowing how students acquire and use knowledge most effectively can help teachers seeking guidance on how to better meet the needs of their students. This can point teachers to the strongest evidence so they can make confident, well-informed and impactful teaching decisions.

The information in this paper supports the Australian Professional Standards for Teachers 1.2: Understand how students learn. Teachers at all career stages can use this overview to affirm, extend or improve their current practice by:

- developing their understanding and use of research on how students learn
- reviewing the structure of their teaching programs using research evidence
- evaluating the effectiveness of teaching practices in their schools to identify opportunities to have a greater impact.

Leaders can also use this paper to develop a common language and shared understanding of how students learn, and to ensure policies and programs are aligned with this evidence to maximise learning for all students.

AERO will develop guidance on the use of these practices in later resources for teachers and schools.

Purpose and approach

This paper provides an overview of how students learn and its implications for teaching. To identify the most effective teaching practices, AERO has drawn on evidence that shows consistent positive impact on learning outcomes for students across diverse contexts (Gonsalkorale, 2022). This evidence is relevant to all school-aged learners and to all classrooms.

This overview of learning processes and teaching implications has been distilled with insights from cognitive science, neuroscience and education psychology, with a focus on sources with practical relevance to classroom teachers in schools.

AERO has identified 4 key areas relevant to classroom teachers:

1. Learning is a change in long-term memory.
2. Students process limited amounts of new information.
3. Students develop and demonstrate mastery.
4. Students are actively engaged when learning.

Within each area, we describe principles of learning and implications for the most effective teaching practices that are proven to maximise learning outcomes.

Evidence on the factors that foster student engagement in the classroom draws on a wide body of research, including research on key factors that influence student learning and success, such as belonging and cultural safety.

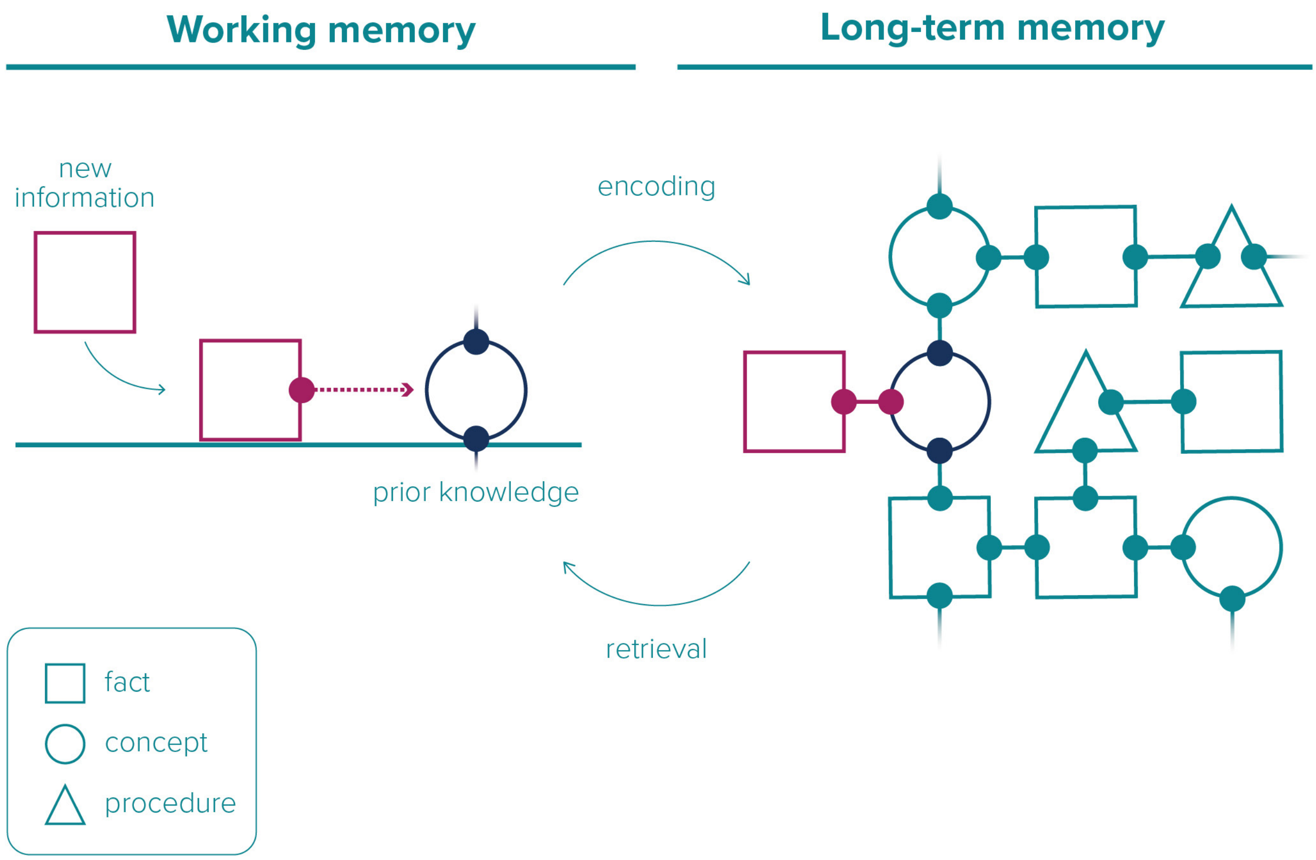
Learning is a change in long-term memory

This section describes how learning changes long-term memory. It explains what effective and efficient learning processes look like, the functions that develop to enable the learning process, and how students build and apply their knowledge in meaningful, creative and complex ways.

Memory is integral to learning

During the learning process, new information is processed in working memory and, under the right conditions, stored as knowledge in long-term memory. Figure 1 shows the process of *encoding*, wherein information is transferred and stored in long-term memory. It also depicts the process of *retrieval*, where knowledge is recalled from long-term memory and actively used.

Figure 1: Information is processed by working memory and transferred as knowledge to long-term memory for later storage and retrieval



Working memory can use both new information and prior knowledge retrieved from long-term memory during the learning process, but it can only process information while it is being thought about and focused on (Cowan, 2008). For example, young students learning about the features of insects might be asked to observe and count their legs. While counting, they focus on the task and draw on procedural knowledge for counting from long-term memory. If distracted from the task, working memory won't retain information. This means the student will need to re-focus their attention on the task before they can complete it again. After repeated encounters with this information – such as writing down observations, sharing with their peers and answering questions from their teacher – over time, they might transfer the factual knowledge that insects have 6 legs to long-term memory.

Long-term memory is a vast network of interconnected knowledge that, once sufficiently consolidated, has the potential to be stored and recalled indefinitely. Consolidation involves establishing multiple and strong connections to specific pieces of information in long-term memory through interaction with working memory over time. This process makes knowledge easier to recall and use (Centre for Education Statistics and Evaluation [CESE], 2017).

Information in long-term memory may be conscious, such as knowledge of facts (semantic memories), experience or events (episodic memories), or the steps to perform a task (procedural memories). Memories can become unconscious once they have been retrieved and used through practise to the point of fluent and automatic recall (Camina & Güell, 2017).

For instance, when learning about the states of matter in science, students acquire semantic memories (for example, knowing that matter takes the forms of liquids, gases or solids), procedural memories (for example, knowing the steps to set up laboratory equipment for an experiment to observe a liquid changing state to a gas), and episodic memories associated with specific experiences (for example, the classmates who were present, time of day during the event, emotions felt, and related contextual experiences). Semantic, procedural and episodic memories may all be developed and drawn on at varying points of the learning process. Various pieces of knowledge in different forms are connected together in long-term memory as students learn about how they relate to one another, further consolidating that knowledge in memory (Camina & Güell, 2017).

Learning starts when students focus their attention to think about new information sensed from the external environment. Students then process this information in their working memory and combine it with knowledge recalled from long-term memory. Working memory is limited and can only hold information while it is being used or attention is focused on it (Craik & Lockhart, 1972; Kirschner & Hendrick, 2020). Working memory also requires rest after processing, or it becomes more limited in its capacity (Chen et al., 2018). For students who experience language or information processing difficulties, or whose capacities to attend and focus are not yet developed, working memory may be even more limited.

The information used by working memory is not limited to new information. Working memory can also use information already learned and retrieved from long-term memory. Newly encountered information is processed in working memory as single pieces. When drawing on familiar information that has already been organised and stored in long-term memory, working memory can retrieve multiple pieces of connected information as a single chunk. For example, students who have already consolidated what they've learnt about the common features of insects in long-term memory can recall those features as a set of connected information, or chunk, from long-term memory. They can use this 'chunk' to examine a new specimen they encounter and decide whether it should be categorised as an insect.

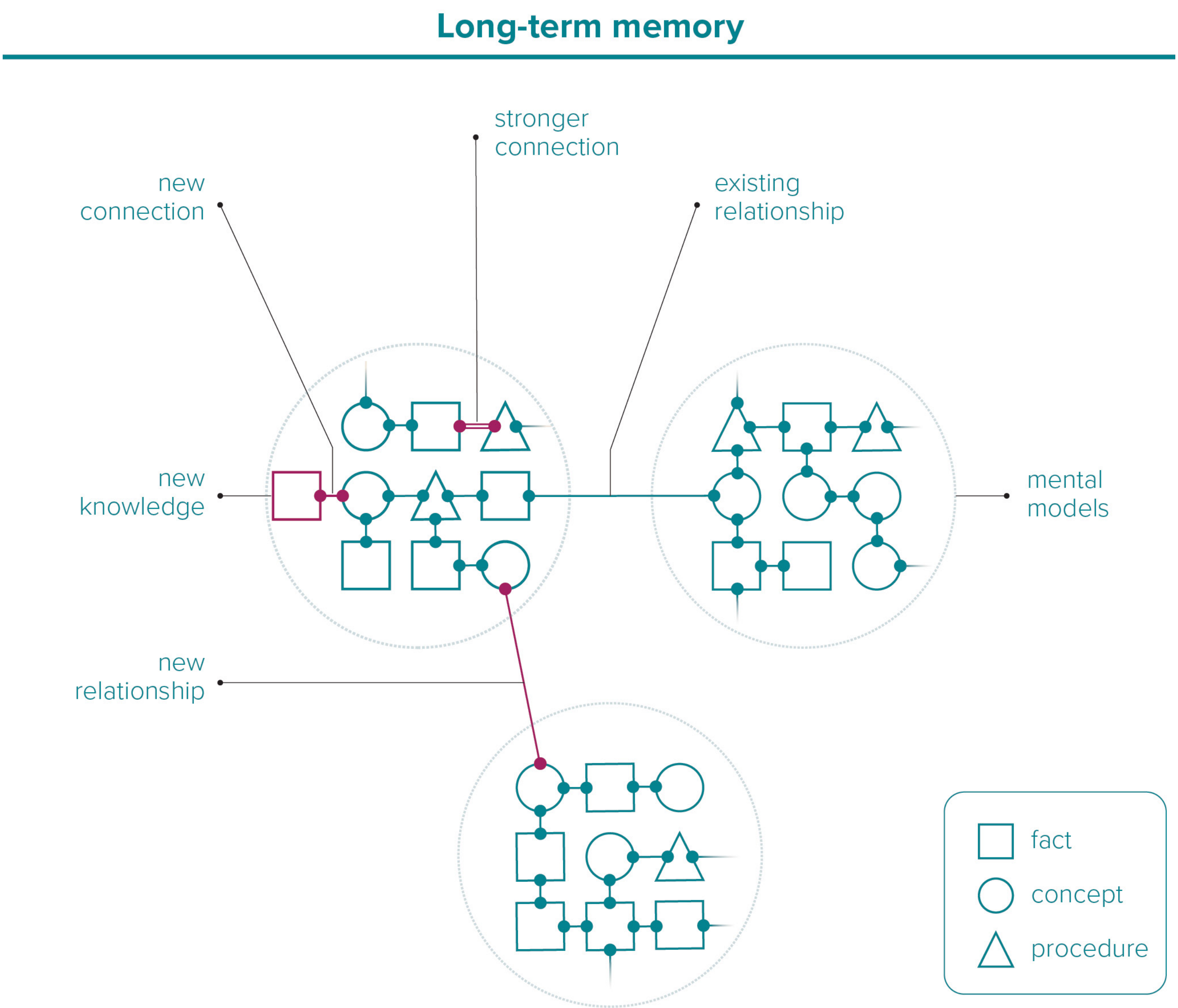
Long-term memory is the place where information is stored to be recalled and used again. People may forget what they have learnt and experience trouble accessing the information, especially if they haven't had enough opportunities to practise and consolidate their learning, but the amount of information that can be stored in long-term memory is vast (Sweller, 2016).

Learning is most effective when allowances are made for the limits of working memory, both by students regulating their own learning and by teachers breaking up and sequencing learning in small chunks that build in complexity. This is the application of cognitive load theory. According to cognitive load theory, when working memory is overloaded, for a range of possible reasons, there is a high risk that the information will not be transferred to long-term memory, will not be connected to and extend current knowledge, and so will not contribute to the student's greater understanding of the area of learning (CESE, 2017). The limits of working memory explain why teaching practices that involve breaking down and sequencing limited amounts of new information, and reducing extraneous detail, support effective learning (Rosenshine, 2012).

Building and connecting knowledge in long-term memory supports effective learning

Understanding how long-term memory interacts with working memory to create lasting change provides insights into how effective teaching fosters meaningful, effective and efficient learning experiences for students. As students focus their attention on new information while they learn, they may be prompted to retrieve prior knowledge of facts, concepts and procedures from their long-term memory and connect these to new information within working memory (P. Brown et al., 2014; Deans for Impact, 2015). During this process, students build mental models that organise knowledge to represent what they understand about the area of learning (Piaget, 2013). As students take in new information, they connect it to other things they know or have experienced and to what they believe (Chi et al., 1981; Kirschner & Hendrick, 2020). Figure 2 shows how information is connected and consolidated in long-term memory to construct mental models.

Figure 2: The connection and consolidation of knowledge in long-term memory to build mental models



Students encountering new information (novices) process this differently to experts – even when both are exposed to the same information (Chi et al., 1981). It takes more time for novices to master new information than experts because they need time to develop their mental models. Once they have a mental model, students can start to move from perceiving what they are learning as isolated pieces of information to recognising how they connect and why relationships exist between them (Chi et al., 1981; Kirschner & Hendrick, 2020). Equipped with a clear mental model, students can then draw on their deeper understanding to facilitate further learning (Fiorella & Mayer, 2016). For example, students who have developed a mental model from learning about the features of insects, then mammals and then reptiles can draw from across these areas of learning to build more complex concepts like the relationships between the features and functions of these different animals, and how these features help them survive in the environments where they live.

Students learn most efficiently when guided by knowledgeable others

While students can acquire knowledge through their own experiences, they learn most efficiently by gaining information from others. Listening to what knowledgeable others say, reading what they write or observing what they do is vastly more efficient for novice learners than self-discovery (Kirschner et al., 2006).

Although they can learn some things through personal experience and self-discovery, student learning is constrained by the limits of their working memory and the amount of prior knowledge they can use to guide and connect learning (Sweller, 2016). When students are novices, engaging in independent, unguided inquiry carries the risk of developing misconceptions that become consolidated as inaccurate and unreliable mental models in long-term memory (Kalyuga, 2007; Sweller et al., 2003). For example, without guidance, students learning about the features of insects might incorrectly identify spiders as insects and retain inaccurate information that insects have either 6 or 8 legs.

By contrast, gaining information from experts, through well-sequenced, logically structured presentation, enables students to learn rapidly, and avoid misconceptions, and makes the learning process both efficient and effective (Kirschner et al., 2006).

Once students have mastered a set of knowledge and built a mental model that connects relevant information together, they are able to apply this to solve unfamiliar problems, extend their mental models further and generate new critical and creative ideas (Fiorella & Mayer, 2016; Sweller, 2016).

People develop functions that support learning

People have evolved to develop certain abilities without formal instruction, such as walking, listening, speaking and taking a basic 'trial and error' approach to generating ideas and solving problems (Geary, 2002, 2005). From early childhood and beyond, young people develop 'executive functions' (AERO, 2023c), such as the ability to plan, focus their attention, and control impulses. (Miyake & Friedman, 2012). These functions are related to students' capacity to learn from others, such as via instruction from their teachers. Learning from others requires students to actively direct and focus their attention where it's needed – whether they are listening to what people say, observing what they do or when they are reading to learn. Executive functions are also important in situations where students need to plan out what they will do, and make decisions, such as when solving problems.

For most young people, the development of executive functions happens rapidly in the early years. For example, the ability to focus attention on something in the environment emerges very early in most young people's development, followed by the ability to use working memory to control where attention is focused. This development is impacted by genetic and environmental factors and the learning experiences of young people from their infancy through to late adolescence, meaning differences in executive functions may persist (Miyake & Friedman, 2012).

As children grow, the learning experiences that are most suited to their stage of development and maturity shift, especially during the significant transition years of early schooling. In a school environment where students are required to learn a great deal of new information to provide the foundation for their continued learning, guidance from a knowledgeable expert, through teacher-led explicit forms of instruction, is most effective and efficient. The knowledge students gain allows them to draw on their learning and apply more sophisticated thinking in increasingly complex ways as their executive functions develop. However, working memory remains limited in capacity. That capacity can't be increased and there will be persistent individual differences in the limitations of students' working memory, as well as differences in executive functions, that need to be accounted for (Melby-Lervåg et al., 2016).

Implications for teaching

To align with the evidence that learning is a change in long-term memory, teachers develop a teaching and learning plan for the knowledge students will acquire. To achieve this, teachers:

- identify the knowledge students will acquire and the relevant prerequisite knowledge
- break up intended learning and sequence it to build in complexity
- develop and plan teaching and learning tasks appropriate for acquiring, retaining and consolidating learning
- plan assessment tasks and processes to monitor progress, attainment and the learning needs of all students.

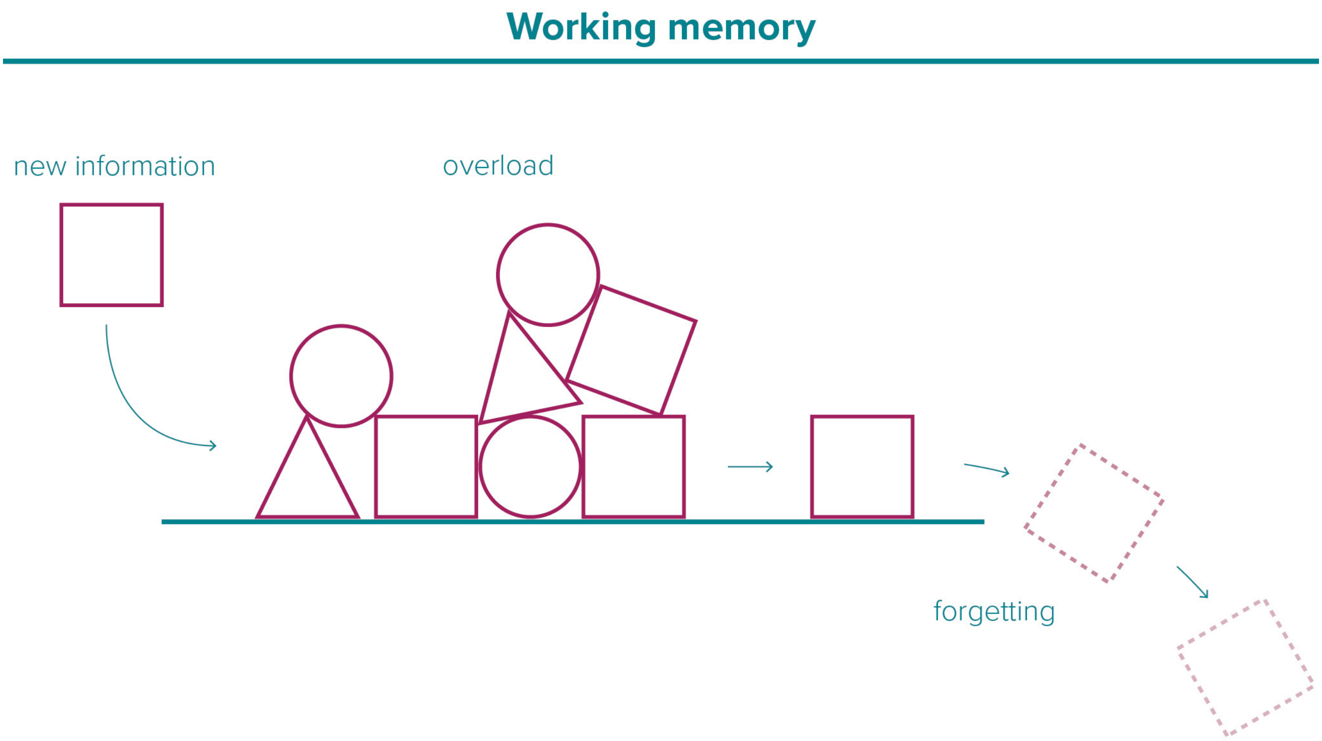
Students process limited amounts of new information

This section explains key practices and conditions that support students to process and retain new information effectively. When teaching accounts for these practices and conditions, student learning is maximised.

Reducing cognitive load supports learning

Cognitive load theory is about maximising learning by designing instruction to account for the limits of students' working memory (Sweller, 1994). The learning process is impeded if working memory is overloaded. Figure 3 demonstrates the limited capacity of working memory to process and transfer new information to long-term memory. If working memory is overloaded, students will not readily connect and store new knowledge in long-term memory, and so will not develop a greater understanding of the area of learning.

Figure 3: The limitations of working memory impact retention in long-term memory



Why students experience cognitive overload

Multiple factors relating to how students are taught and the environment they learn in can lead to cognitive overload (Willingham, 2021). When students are required to process multiple new pieces of information simultaneously, it places a high cognitive load on students' working memory. Students can also experience cognitive overload if they are presented with too much additional information that is not directly relevant to their learning, or when the task is too conceptually difficult for their current level of knowledge and skills (CESE, 2017). Visual and auditory distractions may occupy the mental space of working memory needed to focus on the content of their learning. Additionally, learning environments with unclear behavioural expectations and inconsistent rules and routines can pull students' focus away from their learning (Alter & Haydon, 2017).

Cognitive overload can also happen when students are required to complete new tasks or identify new learning by themselves, without prior instruction, guidance or scaffolding from their teacher. When students receive minimal guidance to complete a new task, their attention may be focused on the process of completing the task, and not on thinking about the new information they need to learn within the task (CESE, 2017). With their focus on task process and completion, students may successfully complete tasks without actually connecting and transferring information within the task to long-term memory (CESE, 2017). The high cognitive load associated with minimally guided approaches to teaching and learning can lead to gaps in learning and misconceptions that need to be corrected. For example, students asked to collate information from various sources to create a slide presentation on an unfamiliar topic, without specific structure and guidance, may later struggle to remember what they found when asked to recall and use the information, because their attention was focused more on the process of developing slides.

Optimising cognitive load

Effective teaching recognises the difficulty of learning tasks and optimises cognitive load by managing the way they are taught. Optimising cognitive load involves:

- breaking up content
- sequencing information logically
- using models, worked examples and other scaffolds
- providing a learning environment that supports focus on learning.

Breaking up and sequencing content logically may include introducing simple elements before more complex parts, providing concrete examples before describing abstract concepts, and by introducing sections of material before the whole (CESE, 2017; Kirschner & Hendrick, 2020; Reigeluth et al., 1980).

Scaffolding is where teachers provide students with more guidance in completing difficult tasks when the students are new to the procedures or concepts being learnt (Rosenshine, 2012). Scaffolds can include models to represent concepts, worked examples to demonstrate the process and goal of completing a task, as well as prompts, information organisers, checklists, and access to reference materials. Scaffolds can be gradually removed as students develop greater proficiency (Perry et al., 2021).

Detailed task analysis may be required to break up, sequence and scaffold content to a level needed for all students to access the content of the curriculum, accounting for differences in students' working memory limitations and other differences in executive functions (Nationally Consistent Collection of Data on School Students with Disability [NCCD], n.d.).

A learning environment that minimises cognitive load will prevent distractions and teach students to adopt effective learning behaviours and routines that allow their attention to be focused on the content of their learning. Students who have learned the behaviours and routines that are expected of them to the point they become unconscious and automatic won't have to think about these things while focused on learning (Chaffee et al., 2017; Simonsen et al., 2008).

Learning mechanisms are the same but prior knowledge and capacities to process information vary

Students' capacity to solve problems and attempt unfamiliar tasks is often impacted by the amount of relevant knowledge they bring (Willingham, 2021). For example, the ability to comprehend and respond to written texts depends greatly on the background knowledge the student already has of the vocabulary and content within the text. This can advantage or disadvantage learners from differing cultural backgrounds, whose prior experiences and knowledge may or may not be represented in the texts used during learning (J. Brown et al., 1989). However, modifying instruction in multiple ways to align with current prior knowledge, interests or preferred activities is not very effective, and is far less efficient for the student and the teacher (Deans for Impact, 2015; Willingham, 2021). Instead, planning teaching and learning programs to sequentially recognise and build on students' prior knowledge, and to explicitly teach new knowledge relevant to the area of learning, supports effective, efficient and consistent learning progress (Rosenshine, 2012). Explicitly teaching knowledge and skills related to the current area of learning can overcome differences in prior knowledge. It can provide more equitable opportunities for all students to apply, demonstrate and extend learning that relies on a strong foundation of knowledge.

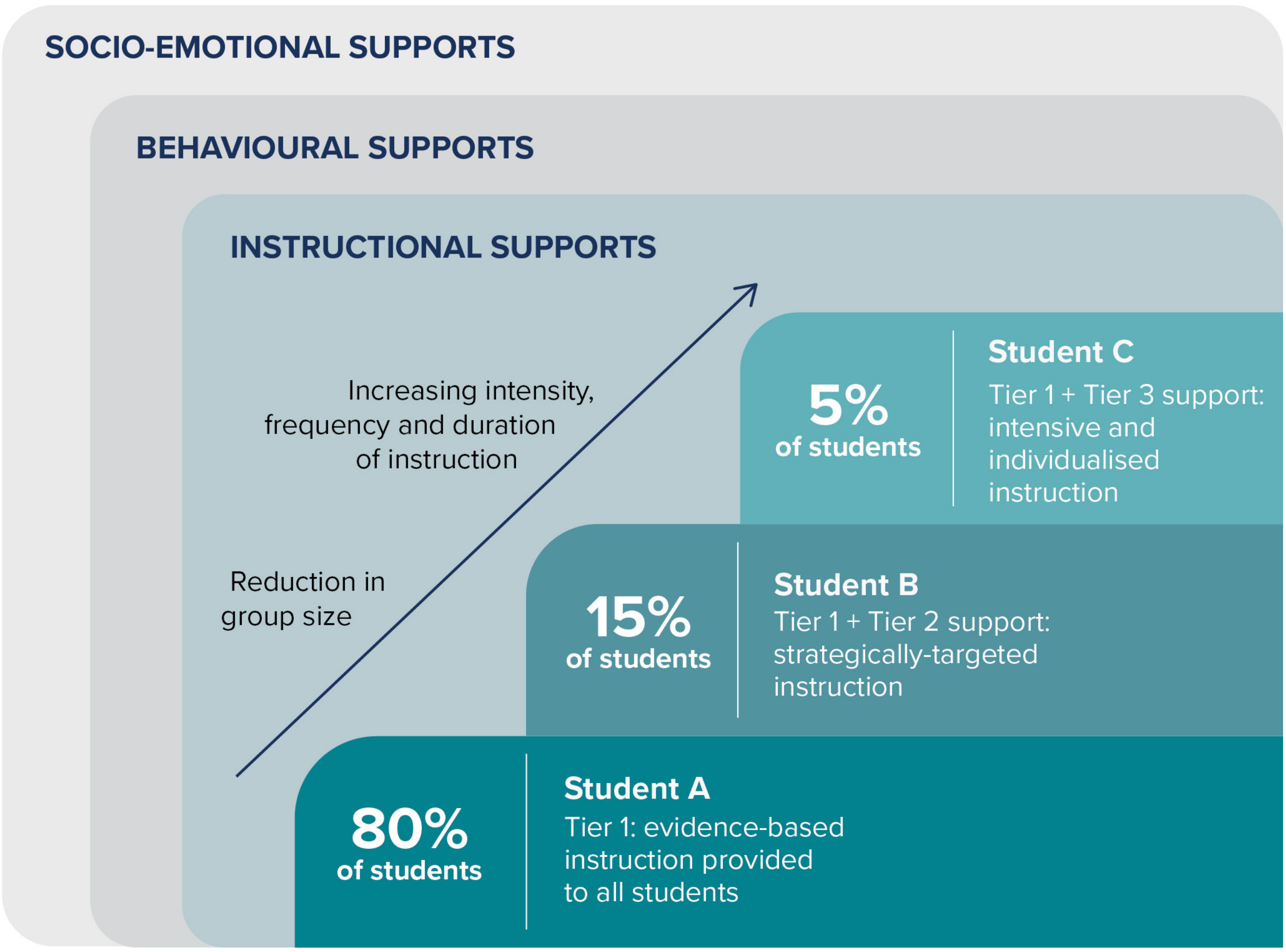
When it comes to how students learn most effectively, the mechanisms for moving information from working memory to long-term memory are the same. This doesn't mean all students are the same and can always learn at the same pace. Individual development of executive functions and capacities for information and language processing can vary. For some students, executive functions are not so well developed and working memory is even more limited, so learning is more challenging. For others, they may bring advanced prior knowledge of a learning area, meaning they have greater capacity to connect and apply their current understanding. Specific intervention for students who experience barriers to learning or have additional learning needs can help to ensure that all students receive the guidance and support, or extension and enrichment, they need (Arias-Gundín & García Llamazares, 2021). For students with disabilities, teacher practice needs to align with the Disability Standards for Education (NCCD, n.d.). In addition to adopting the most effective evidence-based practices for whole-class instruction, making reasonable adjustments for students with disability may include providing increased frequency, intensity and duration of scaffolding and support before they are ready for independent practice. For others, extended opportunities to connect and apply their current understanding will support their continued engagement and learning.

Students with additional learning needs benefit from tiered interventions

Tiered intervention models are used by schools to support teachers in meeting the diverse needs of their students. Response to Intervention (RTI) models focus on providing additional learning opportunities so that all students make the required progress before moving to the next sequence of learning. Multi-tiered system of supports (MTSS) models were developed to go further than RTI models by providing multiple types of support in addition to supporting students to reach learning outcomes, including supports related to behavioural and socio-emotional considerations (Berkeley et al., 2020; Ferrer-Esteban, 2019).

Alongside socio-emotional and behavioural supports, MTSS includes high-quality instructional practices and evidence-based interventions at 3 levels (called 'tiers') that increase in intensity. Instruction within an MTSS model happens at the classroom level, as well as at a school-wide multi-level system of instruction and support (AERO, 2023b). Within an MTSS model, all students have access to interventions, informed by universal screening and monitoring student data. Decisions based on student data provide a framework for organising and accessing interventions, monitoring, celebrating progress and communicating student development (AERO, 2023b). Figure 4 illustrates how tiers of instructional intervention operate in an MTSS framework.

Figure 4: Tiered instruction in a multi-tiered system of supports



The MTSS model includes the following tiers:

- **Tier 1** involves the whole class receiving high-quality instruction. All students have opportunities to learn alongside their peers, with common learning intentions and expectations of learning success. Reasonable adjustments, including scaffolding and guidance, can be made as required. Generally, 80% of students' learning needs can be met effectively at Tier 1, depending on the context of the school (de Bruin et al., 2023).
- **Tier 2** instruction takes place when students have knowledge or skill gaps that prevent them from responding to quality Tier 1 instruction alone. This involves smaller group settings, with students receiving additional evidence-based instructional practices or targeted and relevant support to achieve the learning relevant to their common goals.
- **Tier 3** instruction involves intensive and individualised student support by a staff member trained in evidence-based intervention. Students receive one on one or small group instruction focused on their areas of need.

For more information on MTSS, see AERO's Tiered Interventions guides.

Implications for teaching

To align with the evidence on how students process limited amounts of new information, teachers manage the cognitive load of learning tasks. To achieve this, teachers:

» communicate clear learning objectives and activate prior knowledge

» teach chunks of new information explicitly with explanation, demonstration and modelling

» guide student learning, and gradually remove scaffolds

» check for understanding and give additional instruction, guidance or feedback as needed

» monitor for additional needs and support student access to tiered interventions.

Students develop and demonstrate mastery of their learning

Mastery is the accumulation of knowledge, conceptual understanding and skill, where students both retain knowledge and understand how to use it (P. Brown et al., 2014). This section explains how students develop and demonstrate mastery of their learning by applying the mental models they consolidate in long-term memory through retrieval and practise. When teaching accounts for these processes, students' successful application of learning to more complex tasks supports their continued progress and engagement.

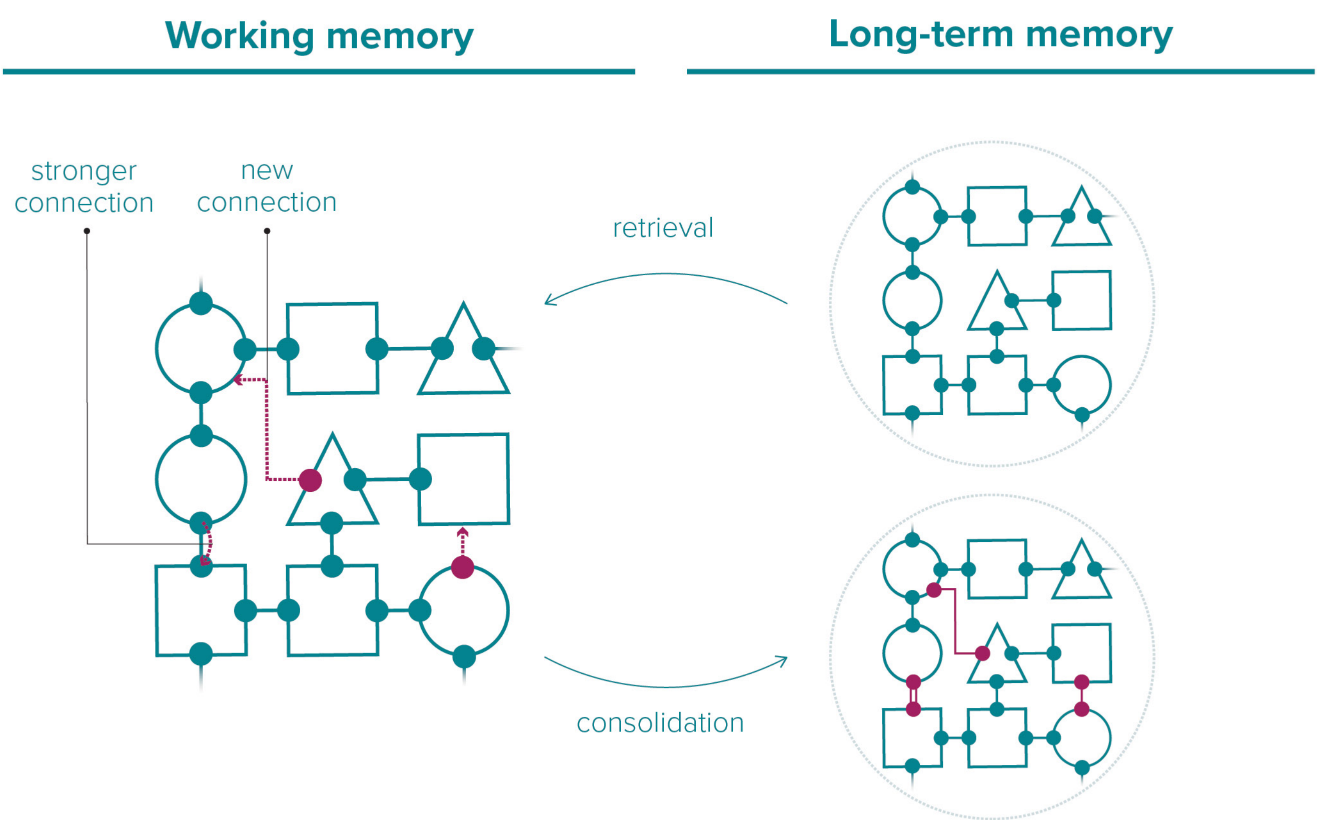
Retrieval promotes retention and consolidation of learning in long-term memory

Retrieval promotes the consolidation of information in long-term memory by bringing what has already been learnt back into working memory, building and strengthening connections within memory.

Retrieval may be prompted by any activity that requires students to recall information from memory rather than re-presenting, re-reading, re-studying or being re-taught the information (P. Brown et al., 2014; Perry et al., 2021). When students are regularly asked to bring information that they have previously learnt to the front of their mind to answer a question, rather than looking up the information or having the teacher explain it again, that information becomes increasingly more accessible in the future. Each new experience recalling knowledge builds and strengthens the connections to it in memory, which in turn develops automatic recall and makes it easier to apply (Rosenshine, 2012). Information that can be automatically recalled from long-term memory does not burden working memory, which makes learning new, related information easier (Sweller, 2016).

Retrieval is more than the repetition of facts; it includes the use of lesson reviews, tests, quizzes, questioning and prompts. When students access their learning and apply their knowledge in different ways, including in response to conceptual and higher-order thinking questions, this also provides the opportunity for retrieval and associated consolidation of long-term memory (P. Brown et al., 2014; Weinstein et al., 2018). Figure 5 shows how new encounters of recalled knowledge encode new connections in long-term memory.

Figure 5: Encoding and retrieval processes consolidate knowledge in long-term memory



Another benefit of retrieval tasks is that, if a student cannot recall the information, it helps the teacher identify learning gaps or misconceptions to be addressed through feedback, additional instruction and guidance (Weinstein et al., 2018).

Spacing practise promotes better recall

Students who experience multiple opportunities for retrieval spaced across a sequence of learning are not only better able to recall knowledge but also consolidate their learning in long-term memory (Carpenter et al., 2022; Weinstein et al., 2018). Spaced retrieval practising can involve a variety of recall tasks over different times.

Retrieval can feel harder and less productive than revisiting the content immediately, but the effort involved helps students to consolidate their learning in long-term memory (P. Brown et al., 2014; Perry et al., 2021). Massed practising or 'cramming', where material is practised in a single session, is less effective for durability and mastery (Weinstein et al., 2018). Massed practising can also negatively impact the limits of working memory, while spacing practising provides the opportunity for working memory to rest and rebuild its capacity for processing information (P. Brown et al., 2014).

Varied practise consolidates and extends student learning

Varied practise involves engaging in tasks and questions that are related but require students to think about and apply what they know in different ways and contexts. Students' ability to transfer learning to new situations is improved by varied practise because it provides a better understanding of different conditions and underlying structures that may be common across situations, despite their differences (P. Brown et al., 2014; Weinstein et al., 2018).

Varied practise consolidates learning better than repeated similar practise because it helps to develop more complex mental models in long-term memory. It helps students develop multiple connections to knowledge in long-term memory, supporting it to be retained, retrieved and applied more easily. Activities such as summarising and concept mapping about the connections between facts, concepts and procedures within an area of learning help students to organise their knowledge in meaningful ways to better support consolidation and recall.

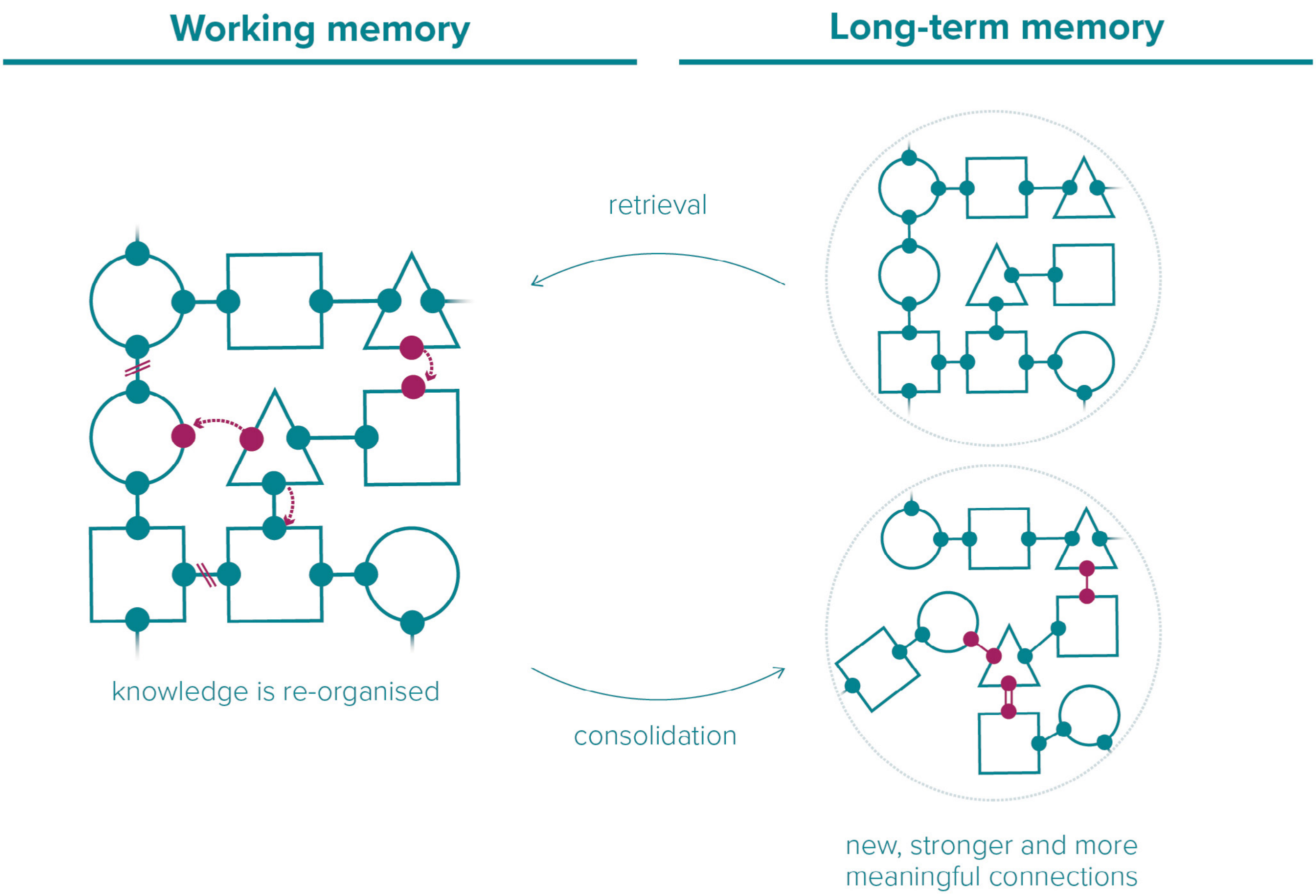
Students build complex and meaningful mental models

Students' understanding of their learning is reflected in the mental models they build in long-term memory. Developing deep understanding and increasingly complex mental models takes time and is dependent on students having opportunities to learn about the relationships between facts, concepts and related procedures with guidance and feedback (Weinstein et al., 2018). Making meaningful connections between knowledge helps students understand what they are learning, why it is important and the context to which it applies (Kirschner & Hendrick, 2020; Reigeluth et al., 1980).

Sequencing learning (from simple ideas, to complex, general information, to detailed and concrete ideas, to abstract concepts) supports students in forming and organising the connections between information to build accurate and useful mental models (Rosenshine, 2012; Weinstein et al., 2018).

Summarising and concept-mapping techniques guide students to organise information in a way that prompts them to examine aspects of a concept, as well as relate it to the big ideas as a whole (P. Brown et al., 2014; Perry et al., 2021). Figure 6 shows how connections are built and extended in long-term memory, as students organise their learning to develop accurate and useful mental models.

Figure 6: The organisation of learning in mental models in long-term memory



Positioning the content of learning within meaningful, authentic and relevant contextual examples aids transfer of learning to real-world applications. These activities enable relationships between knowledge, tasks, contexts and culture to be made explicit (J. Brown et al., 1989; Collins et al., 1991). Students can be supported to better understand these relationships with the use and creation of tools such as advance organisers, concept maps and scaffolds (Ausubel, 1960, 1968).

Authentic, context-relevant learning tasks are also beneficial to support culturally safe learning environments where the diverse cultural identities of students are recognised and valued, including by recognising diverse perspectives on knowledge that might differ from the current area of learning, the perspectives within texts, and the culture in which that knowledge was established (Bodkin-Andrews & Carlson, 2016; J. Brown et al., 1989; Collins et al., 1991). Some examples of recognising diverse perspectives in learning could include teaching letter sounds in a way that recognises diverse pronunciations that differ from Standard Australian English, and teaching about vocabulary in a way that recognises diverse definitions and applications.

Consolidating knowledge in long-term memory activates students' capacity for problem-solving and inquiry

The capacity for basic problem-solving and idea generation that develops from early childhood provides people with the ability to draw on knowledge from long-term memory and combine and recombine that knowledge to generate and test solutions and creative ideas.

When students are confronted with a familiar problem and already have the solution stored in their memory, or a way of easily accessing one, they will quickly search their memory and find a response (Willingham, 2021). When no solution or strategy is easily retrieved, they need to engage in a more effortful process of generating a novel solution or creative idea. A sustained search of consolidated memories will help the student identify potentially relevant knowledge and strategies. As potentially useful memories are accessed, students process the information in working memory and generate possible solutions (Beaty et al., 2015). Existing memories are combined and recombined into novel ideas or strategies that can be used to solve the problem (Willingham, 2021).

Once a potential solution is generated, it is evaluated to check that it is satisfactory, and then that becomes the student's response. If it is not satisfactory, then the student must decide whether to give up, accept a solution as 'good enough', or continue with the processes of search, generation, and test (Ackerman & Thompson, 2017). Novel solutions do not emerge without existing knowledge as a basis (Willingham, 2021).

Given students' capacity for generating and testing ideas using prior knowledge, generalised problem-solving techniques do not need to be a focus for classroom teaching. Instead, helping students to acquire relevant knowledge they can use will enhance their capacity to generate ideas and solve problems effectively (Sweller, 2016). Skills that are a focus for classroom teaching – such as reading, writing and solving mathematical equations – can be taught by developing students' knowledge of facts, concepts and procedures related to those skills, such as phonological awareness, sentence structures and mathematical procedures. Increasingly complex skills such as critical analysis of a text, or creative and persuasive writing, can be supported with knowledge of heuristic methods, strategies or processes relevant to the area of learning that can guide the student as they develop a unique response (Fiorella & Mayer, 2016).

Students who have obtained mastery can generate new learning

Novices and experts benefit from different instructional approaches. Once students have attained a level of expertise, including fluent recall of relevant facts, concepts and procedures, and understanding of the relationships between them, they may benefit from engaging in increasingly independent and complex problem-solving tasks (Kalyuga, 2007; Kirschner et al., 2006) and from applying their knowledge to guided, structured inquiry tasks (Martin & Evans, 2018). Guided, structured inquiry involving contextually relevant examples can also support students' ability to transfer their learning to new and unfamiliar contexts by giving them opportunities to apply and use their existing mental models (J. Brown et al., 1989; Kirschner & Hendrick, 2020). Independent problem-solving and structured inquiry learning are most effective when placed later in the sequence of learning, as a way to apply and extend learning once students have sufficient prior knowledge, rather than as an introductory approach to a new area of learning.

When students draw on and apply the mental models they've developed to new and unfamiliar contexts and tasks, they must go through a process of discerning what is most relevant and integrating the new learning they've gained with what they already know. This requires them to make sense of what they've found by re-organising their existing mental models, building meaningful new connections. This process is known as generative learning, named for the fact that students can – once they have the necessary depth of knowledge and understanding – generate new learning beyond what they've been explicitly taught (Fiorella & Mayer, 2016). Techniques that support students to engage in generative learning include summarising, concept mapping, drawing, imagining, self-testing, self-explaining, teaching others, enacting and performing. Students benefit from teaching and support to learn how and when to apply specific techniques for generative learning (Fiorella & Mayer, 2016).

Implications for teaching

To align with the evidence on how students develop and demonstrate mastery, teachers maximise retention, consolidation and application of learning. To do this, teachers:

» regularly revisit, review and monitor learning progress

» space and vary tasks for guided and independent student practise

» teach the connections between ideas, using models and tasks that build in complexity, detail and abstraction

» provide appropriately challenging opportunities for students to apply, extend and demonstrate mastery of their learning.

Students are actively engaged when learning

This section explains how students' active and sustained presence, focus and attention are required for learning to be successful. Evidence-based teaching practices help to foster the conditions for students' active and sustained engagement and maximise student learning in ways that foster their self-efficacy, their sense of belonging and continued engagement.

Learning requires focus and attention

Learning requires active engagement and sustained focus to move new information from working memory to long-term memory. Effective classroom environments allow students to prioritise thinking about what they are learning, while minimising distractions that can contribute to cognitive load (CESE 2017; McDonald, 2019).

Teachers can guide students to develop habits and follow routines that will support their learning. With this explicit support from teachers – and from their wider community – students can learn to adopt positive learning routines and behaviours and to develop the positive dispositions required to be engaged and successful learners (McDonald, 2019).

The values of the school community should form a basis for the establishment of rules and routines to create effective and appropriate conditions for focusing on learning. For example, while eye contact may be routinely expected by many teachers during learning interactions, avoidance of eye contact is a gesture of respect for many Aboriginal and Torres Strait Islander people, and neurodiversity among students can result in different presentations of what active listening looks like in a classroom setting. It is important that teachers recognise and value diverse student and community perspectives to create classroom conditions that are inclusive, culturally safe and conducive to learning (Australian Institute for Teaching and School Leadership [AITSL], 2022).

Students need to feel accepted, valued and have a positive sense of belonging to sustain their attention and focus within the learning environment, and to then process and retain new knowledge effectively. The sense of belonging that students experience within their learning environment can have a positive impact on psychological safety, motivation and effort. Through demonstrating respectful communication and behaviour, teachers can nurture positive relationships and a sense of belonging for students. Teachers affirm the belief that all students can experience learning success when their needs are met by:

- holding and communicating high expectations of their students
- considering how they conduct themselves in their role as the teacher and in how they respond to situations that arise
- inviting and responding to input and feedback from students on their experiences and needs.

This approach to building and sustaining high expectations fosters belonging, positive relationships and effective teaching and learning (AERO 2023a; Cobb & Krownapple, 2019; Healey & Stroman, 2021; Miller & Steele, 2021).

Success in learning fosters self-efficacy and ongoing engagement

Teachers can support positive learning dispositions and motivation by sequencing and structuring their instruction with clear and relevant learning goals. A desirable level of difficulty is important because, if learning is too difficult, then students may believe they are not good at learning or not intelligent enough to learn (P. Brown et al., 2014; Willingham, 2021). These feelings can discourage students from engaging in learning opportunities. As students demonstrate mastery in their learning and are recognised for their growing knowledge, skills, talents and abilities, their personal experiences of success contribute to their developing self-efficacy.

Learning can be a difficult process, and students may not always appear to enjoy it (P. Brown et al., 2014). Students who are supported to persevere through difficulties experience sustained benefits by developing foundations of knowledge to build on. They can develop resilience that helps them persevere in the future. Monitoring learning progress and being responsive to students' learning needs through formative assessment can support ongoing engagement (Rosenshine, 2012; Weinstein et al., 2018).

Students' beliefs about their ability to learn influence effort

Students' beliefs about their own potential and ability to learn affect their motivation to engage in learning opportunities. Students are more likely to feel motivated to engage when they understand that their ability and intelligence are not fixed but can be improved through effort (Deans for Impact, 2015).

Various factors can contribute to students' negative self-image of their learning potential. Students who are struggling may doubt their potential, even when they have similar intelligence to other students (Willingham, 2021). Differences in self-image can be related to differences in relevant prior knowledge, motivation and access to learning resources and opportunities outside of school (Willingham, 2021).

While students do differ in intelligence, sustained effort can improve their abilities. Students who recognise the malleability of their ability are more likely to interpret an initial failure to achieve as evidence that more practise and effort are required, rather than as evidence that they are not smart enough to succeed (Willingham, 2021).

When teachers communicate high expectations of learners and explicitly teach students to adopt effective learning behaviours, habits and routines (tailored to their own needs), students are more likely to persevere and develop a positive attitude towards learning (McDonald, 2019).

Students can learn techniques to self-regulate their learning

Students who are taught specific techniques to regulate and improve their own learning develop a greater sense of self-efficacy. Developing effective learning techniques supports both students who are struggling to achieve mastery to retain new learning more effectively, and those who have mastered their learning to apply and extend their learning.

Students can adopt techniques to aid their own learning, such as planning for, monitoring and evaluating their own learning progress (Education Endowment Foundation, 2018). This can be taught by teachers modelling and guiding students to define goals, monitor their progress and recognise where their efforts to learn lead to successful results.

Student perception and confidence in what they know is commonly influenced by the extent to which they have engaged in massed practise or cramming. These ineffective techniques for reviewing learning can leave students with a false impression of how much they understand and are ready to apply (P. Brown et al., 2014).

Students can be taught effective techniques for self-regulation of their learning that help them recognise what they do and do not know, and what they need to focus on next. For example, for younger students, this could include providing them with scaffolds and prompts for checking their own work and developing agreed routines for seeking assistance and feedback when it's needed (Education Endowment Foundation, 2018). For older students, techniques could also involve them keeping records and monitoring learning, structuring their environment to make learning easier, and rewarding themselves for success (Effeney et al., 2013; Kirschner & Hendrick, 2020; Zimmerman, 1989). These techniques can also help students identify gaps and areas where they need more practise for themselves and share their progress with their teacher to receive additional guidance when needed (Deans for Impact, 2015).

Stress can positively or negatively influence learning

Stress can influence the learning process in positive or negative ways depending on the timing and level of stress experienced. A small amount of stress – such as from an appropriate level of challenge while exploring new information – can enhance students' ability to form memory (Vogel & Schwabe, 2016). However, even low levels of stress can impede the ability of a student to retrieve information from their long-term memory.

High levels of stress or chronic stress at any point in the learning process can also hinder the students' thinking, making the transfer of information between working and long-term memory more difficult (Vogel & Schwabe, 2016). This explains some of the difficulties students encounter when trying to learn and remember in stressful environments or during periods of long-term stress. The well-documented experiences and impacts of racism in schools are an example of how a stressful environment interferes with students' abilities to sustain engagement and learn effectively (Bodkin-Andrews & Carlson, 2016; Moodie et al., 2019).

Developmental trauma can also impede learning and affect behaviour. Students impacted by trauma may have difficulties with memory, attention, planning, regulating emotions and problem-solving (CESE, 2020). To best support these students, teachers can adopt teaching approaches that recognise the additional limitations students may experience in memory and functions that support learning, such as the ability to plan and regulate emotions during learning.

Cultural safety creates conditions for success in learning

Cultural safety within the learning environment is essential to provide a foundation upon which all learners can succeed. Learning is hindered if schools reproduce racialised structures of inequity and exclusion (Ladson-Billings, 2008). Cultural safety is experienced when an environment is created that is psychologically, socially, physically and emotionally safe for students, their families and their communities. A culturally safe environment is one where there is no threat to, assault on, challenge or denial of cultural identity (Moodie et al., 2019; Williams, 2019).

People are more motivated to learn when they can see the usefulness and relevance of what they are learning. The Australian Curriculum has been developed to define the body of knowledge considered to be important for all young Australians to learn. The Australian Curriculum (Australian Curriculum, Assessment and Reporting Authority, 2023) prioritises Aboriginal and Torres Strait Islander students being able to see themselves, their identities and their cultures in each learning area. Aboriginal and Torres Strait Islander Histories and Cultures have been included as a cross-curriculum priority to ensure that all students can recognise and respect Aboriginal history, culture, knowledge and understanding.

Ensuring consistently high learning and behavioural expectations for all students, regardless of their cultural or linguistic background, is essential to motivate students. High expectations of all students also prevent the reinforcement of damaging stereotypes (Ladson-Billings, 2008; Miller & Steele, 2021). A lack of cultural safety may deny Aboriginal and Torres Strait Islander students from accessing the same learning opportunities as other students (Rigney, 2017). Cultural responsiveness maintains high expectations accompanied by commensurate support and can provide a solid foundation for learning success (AITSL, 2022; Ladson-Billings et al., 2013; Sarra et al., 2020).

It is important to recognise that students, families and communities may have different aspirations and definitions of success in learning. This is especially relevant for First Nations young people, who are learning within an Australian education system that was never designed for them (AITSL, 2022).

Education should not restrict First Nations students to having to choose between either pursuing academic success or sustaining their identity and cultural knowledge base (Price, 2019; Vass et al., 2019). Educational success for First Nations children and young people should be understood as education that:

- enables students to be strong and happy in their own identities and cultures
- ensures students feel known, understood and supported by their teachers and schools with whom they have built positive relationships
- builds on this foundation to equip students to hold aspirations and to navigate the contemporary global world.

Engaging with First Nations children and young people, their families and their communities can support understanding of learning needs, aspirations and definitions of success, and their ongoing and active engagement. Members of the school community determine whether classrooms, schools, practices, policies, organisations, or systems are culturally safe for them, and mechanisms to hear and respond to their voices and perspectives can improve and sustain the cultural safety of the learning environment.

Families may be partners in young people's learning

Families may play a critical role in their child's learning. Fostering family engagement has a positive impact on learning. The most promising family engagement approaches to impact learning outcomes at both primary and secondary school levels involve:

- recognising and supporting family engagement in learning at home
- supporting two-way, positive, meaningful communication
- providing light touch updates about learning
- collaboratively planning and problem-solving with families.

Implications for teachers

To align with the evidence that students are actively engaged when learning, teachers foster the conditions of a learning-focused environment. To do this, teachers:

» maintain high expectations and engagement for all with evidence-based practices that maximise and recognise learning success

» establish rules and routines that support students to focus on learning

» demonstrate respectful communication and behaviour, respond to feedback, and foster a positive sense of belonging

» teach techniques that develop students' capacity to improve their own learning

» develop cultural responsiveness to meet the learning needs and aspirations of First Nations students

» collaboratively plan and communicate with families.

Conclusion

There is a strong body of evidence from cognitive science, neuroscience, and education psychology about how students learn, which helps to explain why some teaching practices have a greater positive impact on learning outcomes than others. This paper connects this understanding of how students learn with practical implications for teachers.

These implications have been identified as the key practices listed throughout this paper and are summarised here:

1. To align with the evidence that **learning is a change in long-term memory**, teachers develop a **teaching and learning plan for the knowledge students will acquire**.
2. To align with the evidence that **students process limited amounts of new information**, teachers **manage the cognitive load of learning tasks**.
3. To align with the evidence on how **students develop and demonstrate mastery**, teachers **maximise retention, consolidation and application of learning**.
4. To align with the evidence that **students are actively engaged when learning**, teachers **create a learning-focused environment**.

Teaching that aligns with how students learn accounts for where students are in the learning process. It considers and monitors what students have already learned and retained in memory, and manages cognitive load so students can effectively process new information. In practice, this means that there is a focus on explicit teaching and guided practice while students are learning new information, and a gradual release of active guidance as students master their learning and are ready to extend and apply it with greater independence. The balance of time spent with sustained focus on the teacher and the level of guidance and support offered is appropriate to students' stage of development and to differences in learning needs. Students are supported and guided in thinking about what they are learning, in a learning-focused environment that doesn't add stress or cognitive load.

Effective teaching recognises that teaching is only effective once students have learned, and not just when information has been taught. This means interacting with students as they practise, monitoring progress and adjusting teaching to meet learning needs as they arise. It means providing students with multiple opportunities to review and revisit their learning so that all students have the best chance of reaching mastery, even those who need more time and guidance.

Rather than a primary focus on the retention of facts, students have opportunities to recognise the context and relationships within their learning, and to build meaningful connections in memory that support their ability to recall and transfer learning to varied tasks and situations. The strong foundation of knowledge equips all students with the opportunity to engage in deeper learning. Active exchanges between the teacher during explicit teaching include a variety of methods such as questioning, elaborating, thinking aloud and peer-sharing while the teacher checks for understanding and responds to student needs with relevant levels of instruction, scaffolding, feedback and guidance.

Despite the important role of teachers in supporting learning, this doesn't mean students learn best in isolation from their peers. Effective teaching includes flexible grouping of students to focus on tasks most relevant to their current need for guidance, explanation and support. As students master their learning, exploration and sharing of ideas to generate and test new insights together supports students to extend their learning in collaboration with their teachers and their peers.

The important learning principles and teaching practices described in this paper recognise that all students benefit from evidence-based practices that align with the mechanisms of memory that allow for acquiring, retaining, retrieving and consolidating learning. They also recognise that student engagement and learning have a reciprocal relationship, and that students learn best in safe and supportive learning environments.

References

Ackerman, R., & Thompson, V. (2017). Meta-reasoning: Shedding meta-cognitive light on reasoning research. In L. J. Ball & V.A. Thompson (Eds.), *The Routledge international handbook of thinking and reasoning* (pp. 1–15). Routledge.

Alter, P., & Haydon, T. (2017). Characteristics of effective classroom rules: A review of the literature. *Teacher Education and Special Education*, *40*(2), 114–127. https://doi.org/10.1177/0888406417700962

Arias-Gundín, O., & García Llamazares, A. (2021). Efficacy of the RtI model in the treatment of reading learning disabilities. *Education Sciences*, *11*(5). Article 209. https://doi.org/10.3390/educsci11050209

Australian Curriculum, Assessment and Reporting Authority. (2023). *Australian Curriculum V9*. https://v9.australiancurriculum.edu.au/

Australian Education Research Organisation. (2023a). *Encouraging a sense of belonging and connectedness in secondary schools*. https://www.edresearch.edu.au/resources/encouraging-sense-belonging-and-connectedness-secondary-schools

Australian Education Research Organisation. (2023b). *Introduction to multi-tiered system of supports*. https://www.edresearch.edu.au/resources/intro-multi-tiered-system-supports

Australian Government Department of Education, Skills and Employment (2019). *The Alice Springs (Mparntwe) education declaration*. https://www.education.gov.au/alice-springs-mparntwe-education-declaration/resources/alice-springs-mparntwe-education-declaration

Australian Institute for Teaching and School Leadership. (2022). *Building a culturally responsive Australian teaching workforce*. https://www.aitsl.edu.au/teach/intercultural-development/building-a-culturally-responsive-australian-teaching-workforce

Ausubel, D. P. (1960). The use of advance organizers in the learning and retention of meaningful verbal material. *Journal of Educational Psychology*, *51*(5), 267–272. https://doi.org/10.1037/h0046669

Ausubel, D. P. (1968). *Educational psychology: A cognitive view*. New York.

Beaty, R. E., Benedek, M., Kaufman, S. B., & Silvia, P. J. (2015). Default and executive network coupling supports creative idea production. *Scientific Reports*, *5*, Article 10964. https://doi.org/10.1038/srep10964

Berkeley, S., Scanlon, D., Bailey, T. R., Sutton, J. C., & Sacco, D. M. (2020). A snapshot of RTI implementation a decade later: New picture, same story. *Journal of Learning Disabilities*, *53*(5), 332–342. https://doi.org/10.1177/0022219420915867

Bodkin-Andrews, G., & Carlson, B. (2016). The legacy of racism and indigenous Australian identity within education. *Race Ethnicity and Education*, *19*(4), 784–807. https://doi.org/10.1080/13613324.2014.969224

Brown, J., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, *18*(1), 32–42.

Brown, P., Roediger, H. L., & McDaniel, M. (2014). *Make it stick: The science of successful learning*. Belknap Press.

Camina, E., & Güell, F. (2017). The neuroanatomical, neurophysiological and psychological basis of memory: Current models and their origins. *Frontiers in Pharmacology*, *8*. https://doi.org/10.3389/fphar.2017.00438

Carpenter, S. K., Pan, S. C., & Butler, A. C. (2022). The science of effective learning with spacing and retrieval practice. *Nature Reviews Psychology*, *1*(9), 496–511. https://doi.org/10.1038/s44159-022-00089-1

Centre for Education Statistics and Evaluation. (2017). *Cognitive load theory: Research that teachers really need to understand*. NSW Department of Education. https://education.nsw.gov.au/about-us/educational-data/cese/publications/literature-reviews/cognitive-load-theory.html

Centre for Education Statistics and Evaluation. (2020). *Trauma-informed practice in schools: An explainer*. NSW Department of Education. https://education.nsw.gov.au/about-us/education-data-and-research/cese/publications/research-reports/trauma-informed-practice-in-schools.html

Chaffee, R. K., Briesch, A. M., Johnson, A. H., & Volpe, R. J. (2017). A meta-analysis of class-wide interventions for supporting student behavior. *School Psychology Review*, *46*(2), 149–164. https://doi.org/10.17105/SPR-2017-0015.V46-2

Chen, O., Castro-Alonso, J. C., Paas, F., & Sweller, J. (2018). Extending cognitive load theory to incorporate working memory resource depletion: Evidence from the spacing effect. *Educational Psychology Review*, *30*(2), 483–501. https://doi.org/10.1007/s10648-017-9426-2

Chi, M. T. H., Feltovich, P. J., & Glaser, R. (1981). Categorization and representation of physics problems by experts and novices. *Cognitive Science*, *5*(2), 121–152. https://doi.org/10.1207/s15516709cog0502_2

Cobb, F., & Krownapple, J. (2019). *Belonging through a culture of dignity: The keys to successful equity implementation*. Mimi & Todd Press.

Collins, A., Brown, J. S., & Holum, A. (1991). Cognitive apprenticeship: Making thinking visible. *American Educator*, *15*(3), 6–11, 38–46.

Cowan, N. (2008). What are the differences between long-term, short-term, and working memory? In W. S. Sossin, J.-C. Lacaille, V. F. Castellucci & S. Belleville (Eds.), *Progress in Brain Research: Vol. 169. Essence of Memory* (pp. 323–338). Elsevier. https://doi.org/10.1016/S0079-6123(07)00020-9

de Bruin, K., Kestel, E., Francis, M. A., Forgasz, H., & Fries, R. (2023). *Supporting students significantly behind in literacy and numeracy: A review of evidence-based approaches*. Australian Education Research Organisation. https://www.edresearch.edu.au/resources/supporting-students-significantly-behind-literacy-and-numeracy

Deans for Impact. (2015). *The science of learning*. https://deansforimpact.org/resources/the-science-of-learning/

Education Endowment Foundation. (2018). *Metacognition and self-regulated learning guidance report*. https://educationendowmentfoundation.org.uk/education-evidence/guidance-reports/metacognition

Effeney, G., Carroll, A., & Bahr, N. (2013). Self-regulated learning and executive function: Exploring the relationships in a sample of adolescent males. *Educational Psychology*, *33*(7), 773–796. https://doi.org/10.1080/01443410.2013.785054

Ferrer-Esteban, G. (2019). *Multi-tiered interventions and forms of support for meeting educational needs: What works to improve learning and reduce school dropout levels?* Ivàlua and the Jaume Bofill Foundation. https://fundaciobofill.cat/uploads/docs/3/1/r/9/6/6/i/4/w/multitiredintervententions_qf15.pdf

Fiorella, L., & Mayer, R. E. (2016). Eight ways to promote generative learning. *Educational Psychology Review*, *28*(4), 717–741. https://doi.org/10.1007/s10648-015-9348-9

Geary, D. C. (2002). Principles of evolutionary educational psychology. *Learning and Individual Differences*, *12*(4), 317–345. https://doi.org/10.1016/S1041-6080(02)00046-8

Geary, D. C. (2005). *The origin of mind: Evolution of brain, cognition, and general intelligence*. American Psychological Association.

Healey, K., & Stroman, C. (2021). *Structures for belonging: A synthesis of research on belonging-supportive learning environments*. Student Experience Research Network. https://studentexperiencenetwork.org/research_library/structures-for-belonging-a-synthesis-of-research-on-belonging-supportive-learning-environments/

Kalyuga, S. (2007). Expertise reversal effect and its implications for learner-tailored instruction. *Educational Psychology Review*, *19*(4), 509–539. https://doi.org/10.1007/s10648-007-9054-3

Kirschner, P. A., & Hendrick, C. (2020). *How learning happens: Seminal works in educational psychology and what they mean in practice*. Routledge. https://doi.org/10.4324/9780429061523

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*(2), 75–86. https://doi.org/10.1207/s15326985ep4102_1

Ladson-Billings, G. (2008). 'Yes, but how do we do it?': Practicing culturally relevant pedagogy. In W. Ayers, G. Ladson-Billings, G. Michie & P. A. Noguera (Eds.), *City kids, city schools: More reports from the front row* (pp. 162–177). The New Press.

Ladson-Billings, G., Welner, K., & Carter, P. (2013). *Closing the opportunity gap: What America must do to give every child an even chance*. Oxford University Press.

Martin, A. J., & Evans, P. (2018). Load reduction instruction: Exploring a framework that assesses explicit instruction through to independent learning. *Teaching and Teacher Education*, *73*, 203–214. https://doi.org/10.1016/j.tate.2018.03.018

McDonald, T. (2019). *Classroom management: Engaging students in learning*. Oxford University Press.

Melby-Lervåg, M., Redick, T. S., & Hulme, C. (2016). Working memory training does not improve performance on measures of intelligence or other measures of 'far transfer': *Evidence from a meta-analytic review. Perspectives on Psychological Science*, *11*(4). https://doi.org/10.1177/1745691616635612

Miller, L., & Steele, C. (2021). Teaching and learning: There is no one right way, but there are right things to do. In M. Shay & R. Oliver (Eds.), *Indigenous education in Australia: Learning and teaching for deadly futures*. Routledge.

Miyake, A., & Friedman, N. P. (2012). The nature and organization of individual differences in executive functions: Four general conclusions. *Current Directions in Psychological Science*, *21*(1), 8–14. https://doi.org/10.1177/0963721411429458

Moodie, N., Maxwell, J., & Rudolph, S. (2019). The impact of racism on the schooling experiences of Aboriginal and Torres Strait Islander students: A systematic review. *Australian Educational Researcher*, *46*(2), 273–295. https://doi.org/10.1007/s13384-019-00312-8

Nationally Consistent Collection of Data. (n.d.). *Supplementary adjustments*. Retrieved December 7 2022, from https://www.nccd.edu.au/wider-support-materials/supplementary-adjustments

Perry, T., Lea, R., Jørgensen, C. R., Cordingley, P., Shapiro, K., Youdell, D., Harrington, J., Fancourt, A., Crisp, P., Gamble, N., & Pomareda, C. (2021). *Cognitive science in the classroom: Evidence and practice review*. Education Endowment Foundation. https://educationendowmentfoundation.org.uk/education-evidence/evidence-reviews/cognitive-science-approaches-in-the-classroom

Piaget, J. (2013). *Origin of intelligence in the child: Selected works* (Vol. 3). Routledge. https://doi.org/10.4324/9781315006260

Price, K. (2019). A brief history of Aboriginal and Torres Strait Islander education in Australia. In K. Price & J. Rogers (Eds.), *Aboriginal and Torres Strait Islander education: An introduction for the teaching profession* (pp. 1–21). Cambridge University Press. https://doi.org/10.1017/CBO9781139519403.001

Reigeluth, C. M., Merrill, M. D., Wilson, B. G., & Spiller, R. T. (1980). The elaboration theory of instruction: A model for sequencing and synthesizing instruction. *Instructional Science*, *9*(3), 195–219. https://doi.org/10.1007/BF00177327

Rosenshine, B. (2012). Principles of instruction: Research-based strategies that all teachers should know. *American Educator*, *36*(1), 12–19. https://www.aft.org/periodical/american-educator/spring-2012/principles-instruction

Sarra, C., Spillman, D., Jackson, C., Davis, J., & Bray, J. (2020). High-expectations relationships: A foundation for enacting high expectations in all Australian schools. *The Australian Journal of Indigenous Education*, *49*(1), 32–45. https://doi.org/10.1017/jie.2018.10

Simonsen, B., Fairbanks, S., Briesch, A., Myers, D., & Sugai, G. (2008). Evidence-based practices in classroom management: Considerations for research to practice. *Education & Treatment of Children*, *31*(3), 351–380. https://muse.jhu.edu/pub/20/article/240375

Sweller, J. (1994). Cognitive load theory, learning difficulty, and instructional design. *Learning and Instruction*, *4*(4), 295–312. https://doi.org/10.1016/0959-4752(94)90003-5

Sweller, J. (2016). Working memory, long-term memory, and instructional design. *Journal of Applied Research in Memory and Cognition*, *5*(4), 360–367. https://doi.org/10.1016/j.jarmac.2015.12.002

Vass, G., Lowe, K., Burgess, C., Harrison, N., & Moodie, N. (2019). The possibilities and practicalities of professional learning in support of Indigenous student experiences in schooling: A systematic review. *The Australian Educational Researcher*, *46*(2), 341–361. https://doi.org/10.1007/s13384-019-00313-7

Vogel, S., & Schwabe, L. (2016). Learning and memory under stress: Implications for the classroom. *Npj Science of Learning*, *1*(1), Article 16011. https://doi.org/10.1038/npjscilearn.2016.11

Weinstein, Y., Madan, C. R., & Sumeracki, M. A. (2018). Teaching the science of learning. *Cognitive research: Principles and Implications*, *3*(1), Article 2. https://doi.org/10.1186/s41235-017-0087-y

Williams, R. (1999). Cultural safety: What does it mean for our work practice? *Australian and New Zealand Journal of Public Health*, *23*(2), 213–214. https://doi.org/10.1111/j.1467-842X.1999.tb01240.x

Willingham, D. T. (2021). *Why don't students like school? A cognitive scientist answers questions about how the mind works and what it means for the classroom* (2nd ed.). Jossey-Bass.

Zimmerman, B. J. (1989). A social cognitive view of self-regulated academic learning. *Journal of Educational Psychology*, *81*(3), 329–339. https://doi.org/10.1037/0022-0663.81.3.329

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