Explainer

Australian Education Research Organisation

Mastery and application

Students develop and demonstrate mastery of their learning

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Mastery of learning is the accumulation and retention of knowledge, conceptual understanding and skills, and knowing when and how to use them. Application of learning includes transferring information to both familiar and new contexts, which leads to deeper understanding and more sophisticated use of knowledge. Mastery is fundamental to students' achievement in school and their lives beyond formal education.

This explainer outlines how students develop mastery by consolidating knowledge – storing and strengthening it in memory through practice and review – enabling them to solve unfamiliar problems, think critically and creatively, and generate new representations and applications of their understanding.

This explainer is one in a series of 4 that describe the cognitive science evidence of how students learn. Each explainer summarises an element of the student learning process outlined in the Australian Education Research Organisation (AERO)'s Teaching for How Students Learn model of learning and teaching.

Teachers and school leaders can use these explainers to deepen their understanding of the cognitive science of how students learn and consider implications for practice:

Attention and focus
Students are actively engaged when learning

Knowledge and memory
Learning is a change in long-term memory

Retention and recall
Students process limited amounts of new information

Mastery and application
Students develop and demonstrate mastery of their learning

How students develop and demonstrate mastery

Students develop mastery by consolidating their learning in long-term memory, which stores information for extended periods, allowing it to be easily accessed and used (Block & Burns, 1976). Consolidation occurs through retrieval practice, where students actively recall and use learned information (Brown et al., 2014). Spaced, varied and repeated practice helps students build mental models – organised networks of connected facts, concepts and procedures that represent their understanding of a learning area and the relationships within it (Johnson-Laird, 1983).

Mental models become more robust as students connect new knowledge to what they already know, moving from novice to expert (Hattie & Donoghue, 2018). Spaced practice and varied applications help students recall and use knowledge fluently, recognise relationships between facts, concepts and procedures, and transfer knowledge to new situations (Carpenter et al., 2022). Students also generate new representations of their understanding through activities such as summarising, drawing or enacting concepts (Fiorella & Mayer, 2016).

Strong mental models enable students to transfer knowledge to new situations and tackle increasingly complex tasks (Bransford & Schwartz, 1999). Fluent recall of knowledge in long-term memory reduces the load on working memory, which temporarily holds and manipulates immediate information (Rosenshine, 2009). By storing information in long-term memory, students can focus their mental resources on analysing problems, evaluating ideas and generating novel solutions. Students demonstrate mastery by applying their learning in meaningful ways, such as solving new problems, creating visual representations, generating summaries and explaining concepts in their own words (Nokes-Malach & Mestre, 2013).

Regular practice spaced over time helps students retain knowledge better than concentrated practice like cramming (Carpenter et al., 2022). Practice in different contexts builds stronger connections in mental models, helping students see the relevance of their knowledge and apply it to varied situations (Butler et al., 2017).

Success, motivation and progression toward mastery

Successful learning experiences and motivation to learn are mutually reinforcing, gaining momentum as students achieve success, acquire new knowledge and apply it more fluently across complex tasks and contexts. Success in learning activities strengthens mental models and builds confidence to tackle more challenging learning, creating a positive cycle where effective use of knowledge leads to new achievements (Phan, 2011).

When students effectively retrieve and apply their consolidated knowledge, they develop greater self-efficacy – a belief in their ability to learn and succeed (Dunlosky et al., 2013). This self-efficacy begins to develop from the earliest experiences of success and eventually supports engagement with increasingly complex cognitive processes, from solving unfamiliar problems to thinking critically and creatively.

Consolidated knowledge enables learning transfer

Students can use their learning in new situations when they effectively consolidate knowledge in long-term memory (Brown et al., 2014). Strong mental models enable them to recognise patterns and principles across different contexts. This recognition allows students to identify when and how their existing knowledge applies to unfamiliar situations (Engle et al., 2012).

For learning transfer to occur, students need to automate basic knowledge and skills. Automation reduces the strain on working memory, enabling students to analyse similarities between familiar and new contexts, select relevant knowledge and adapt their understanding to new situations, and monitor the effectiveness of their approach (Rosenshine, 2012).

As students develop expertise, their mental models become more sophisticated. They progress from recognising surface features to understanding deeper structural relationships (Hattie & Donoghue, 2018). Varied practice strengthens these mental models, helping students use their learning across a range of situations (Schumacher & Czerwinski, 1992).

Learning transfer is shaped by context

Knowledge and understanding are closely tied to the domains and learning areas they're acquired in (Sweller, 2016). This inherent connection can make it challenging for students to transfer knowledge to new contexts – such as different subject areas, problems or scenarios. For example, students who can solve a maths problem, such as $a = b \div c$, solve for b, may not easily recognise how this procedural knowledge applies to calculating velocities in science.

As students engage with new content, they make sense of it by drawing on related prior knowledge and experiences. Students actively construct understanding by connecting new learning with their existing mental models, identifying relationships across domains and exploring how concepts might apply in varied situations.

When students understand how knowledge functions across different domains and contexts, they develop more flexible and sophisticated mental models that support learning transfer (Perkins & Salomon, 2012). This flexibility allows them to apply their knowledge effectively across a range of tasks, deepening their understanding while maintaining connections to their prior experiences.

Implications for teaching and learning

The ability to transfer knowledge is a crucial educational goal, which enables students to adapt and apply their learning to new challenges in and beyond school (Barnett & Ceci, 2002). Transferring knowledge to unfamiliar contexts places a heavy load on working memory, as students must consider multiple factors to determine whether transfer is appropriate and relevant. Students are more likely to recall and apply their learning to unfamiliar tasks once they've consolidated learning in long-term memory. Fluent and automatic recall frees up cognitive resources to focus on and apply prior learning to new contexts. To support this process, teachers should clearly demonstrate how students' existing knowledge connects to new and unfamiliar applications rather than expecting them to discover these connections on their own.

To support students' progression toward mastery, teachers should:

- regularly revisit and review learning
- space and vary tasks for guided and independent practice
- 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.

Clear and actionable feedback, along with opportunities to revisit concepts, helps students identify gaps in their understanding and refine their mental models. Varied practice across different contexts helps students recognise when and how to apply their knowledge. Repeated exposure to key ideas and applying them to increasingly complex tasks strengthen students' grasp of fundamental principles.

Teaching the connections between ideas is important for building and connecting mental models. Gradually and systematically increasing task complexity ensures students develop robust mental models so they can better identify patterns, apply principles across contexts and build the foundation for advanced problem-solving and idea generation (Johnson-Laird, 1996).

As students progress towards mastery, they can demonstrate their understanding in increasingly sophisticated ways. Automating knowledge in long-term memory enhances their ability to solve complex, unfamiliar problems and generate new insights that reflect deep learning. These skills support lifelong learning and success both in and beyond the classroom.

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