Explainer

Australian Education Research Organisation

Knowledge and memory

Learning is a change in long-term memory

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Learning depends fundamentally on how students process and retain information. Knowledge refers to the facts, concepts and procedures that students acquire through experience and education – their theoretical and practical understanding of subjects. That knowledge is stored in long-term memory so that it can be retrieved for later use.

This explainer explores the critical processes through which students acquire, store and utilise knowledge to develop understanding. Knowing the function of memory systems and the process of acquiring knowledge helps explain how learning is retained over time and supports students' ability to build on what they know. A related explainer highlights that knowledge is central to learning.

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

Memory is integral to learning

Learning occurs when students actively process new information and move it to their long-term memory – the brain's vast storage system – through repetition, elaboration or meaningful connections (Baddeley, 1997). This complex process involves building durable networks of knowledge (Brewer, 1987). That knowledge can consist of unrelated facts or concepts but, more importantly and commonly, it takes the form of interconnected clusters of related information. Students acquire knowledge by integrating new information with existing knowledge in long-term memory. Through this process, they develop increasingly sophisticated mental models – organised frameworks that represent their understanding of concepts and relationships (Johnson-Laird, 2006). These models are stored in long-term memory.

The stages of memory

School learning involves 2 primary memory systems: working memory and long-term memory. Prior to storage in long-term memory, information must first be processed in working memory, which acts as a temporary mental workspace, capable of holding and processing only a small amount of new information at a time – typically around 4 to 7 pieces of information for most learners. This capacity can vary, with some students experiencing an even more limited working memory (Baddeley, 1992). Working memory struggles when overloaded with too much new information, leading to confusion or forgetting (Klingberg, 2009). In this workspace, learners actively process new information and connect it to knowledge retrieved from storage in long-term memory (Baddeley, 2012). Without sustained attention and transfer to long-term memory, new information quickly fades (Baddeley, 1992).

The capacity for storing knowledge in long-term memory is very large, with unknown limits. It can be strengthened through practice and review – a process known as consolidation. This process enables students to retrieve information indefinitely (Roediger & Butler, 2011). Knowledge in long-term memory exists in 3 main forms (Baddeley, 1997):

- **semantic memory** stores conceptual knowledge, facts and abstract ideas
- **procedural memory** contains learned processes and automatic routines
- **episodic memory** records contextual experiences and personal events, creating a rich and interconnected repository of stored information (Conway, 2009).

In addition to these individual stages of memory, First Nations knowledge systems demonstrate advanced methods of memory and knowledge transmission across generations (Kearney, 2012). These systems include rich and adaptable cultural traditions and practices such as storytelling, ceremony and connection to Country, integrating multiple memory types to retain and transfer knowledge effectively (Shay & Oliver, 2021). Traditional approaches have successfully preserved complex information over time and acknowledging this in classrooms can help to create inclusive and culturally safe learning environments.

Building knowledge through mental models

Learners develop understanding by forming networks of related information in long-term memory, strengthened through repeated activation of neural pathways (Dudai, 2003; Gabrieli, 1998). When learners encounter new information, they process it in working memory while drawing on existing knowledge to build and refine mental models. These mental models reduce strain on working memory, enabling learners to focus on building new connections and understanding more complex concepts (Sweller et al., 1998).

The sophistication and accuracy of mental models determine how efficiently learners access and apply knowledge (Bucciarelli, 2007; Vosniadou, 1992). Well-developed mental models enable learners to access and apply learned information more efficiently (Sweller et al., 1998). As learners build and refine their mental models, they develop a foundation for recognising patterns, transferring knowledge across different subject areas and generating new insights.

Knowledge building process

Building knowledge relies on several key principles established through cognitive science (Chan & van Aalst, 2018). For learners to process new information effectively, it must connect meaningfully to their prior knowledge and build upon their existing mental models.

Knowledge is acquired in a logical and structured way when learning follows predictable progression patterns, moving from understanding foundational concepts to more complex applications. Such progression enables learners to integrate new information, refine their mental models and apply knowledge across contexts. Understanding these patterns is important in all areas of study, but particularly in areas like maths and science. These subjects are sequential, meaning gaps in foundational knowledge can significantly hinder future learning (Kirschner et al., 2006). For example, missing knowledge about one historical era may not prevent students from learning about others, but failing to grasp key aspects of maths can impede their ability to progress further in the subject.

Implications for teaching and learning

Understanding how memory and knowledge-building processes work provides clear guidance for structuring and sequencing learning content. Teachers should identify the knowledge and skills students will acquire and ensure they teach, activate and make connections with the relevant prerequisite knowledge needed for success. Decades of research highlights that linking new information to prior knowledge supports deeper learning and helps students build more robust mental models (e.g., Braithwaite & Goldstone, 2015).

Well-designed learning content breaks information into manageable chunks and makes explicit connections to students' existing knowledge (Baddeley, 2012). Learning sequences should be logically organised with clear connections between concepts that gradually increase in complexity, enabling students to build on foundational knowledge and progress toward deeper conceptual understanding (Hattie & Donoghue, 2016). Carefully sequenced content not only improves immediate learning but also strengthens long-term retention.

Frequent opportunities to retrieve and apply knowledge in varied ways are essential for strengthening memory consolidation and making information easier to access in the future. Students can also be taught to regularly review their own learning, including through retrieval practice activities like self-testing. Similarly, planning for formative assessment ensures that teachers can monitor progress, identify gaps and adjust instruction to support student learning.

Incorporating diverse cultural perspectives on knowledge transmission can further enhance learning outcomes. First Nations pedagogies offer sophisticated methods of knowledge construction and memory that have successfully preserved complex information over generations. Recognising these approaches can help to promote inclusive and culturally safe learning environments.

References

Baddeley, A. D. (2012). Working memory: Theories, models, and controversies. *Annual Review of Psychology, 63*, 1–29. https://doi.org/10.1146/annurev-psych-120710-100422

Baddeley, A. D. (1997). *Human memory: Theory and practice*. Psychology Press.

Baddeley, A. (1992). Working memory: The interface between memory and cognition. *Journal of Cognitive Neuroscience, 4*(3), 281–288. https://doi.org/10.1162/jocn.1992.4.3.281

Braithwaite, D. W., & Goldstone, R. L. (2015). Effects of variation and prior knowledge on abstract concept learning. *Cognition and Instruction, 33*(3), 226–256. https://doi.org/10.1080/07370008.2015.1067215

Brewer, W. F. (1987). Schemas versus mental models in human memory. In P. Morris (Ed.). *Modelling cognition* (pp. 187–197). Oxford University Press.

Bucciarelli, M. (2007). How the construction of mental models improves learning. *Mind & Society, 6*(1), 67–89. https://doi.org/10.1007/s11299-006-0026-y

Chan, C., & van Aalst, J. (2018). Knowledge building: Theory, design, and analysis. In F. Fischer, C. Hmelo-Silver, S. Goldman, & P. Reimann (Eds.), *International Handbook of the Learning Sciences* (pp. 295–307). Routledge.

Conway, M. A. (2009). Episodic memories. *Neuropsychologia, 47*(11), 2305–2313. https://doi.org/10.1016/j.neuropsychologia.2009.02.003

Dudai, Y. (2003). The neurobiology of consolidations, or, how stable is the engram? *Annual Review of Psychology, 55*, 51–86. https://doi.org/10.1146/annurev.psych.55.090902.142050

Gabrieli, J. D. (1998). Cognitive neuroscience of human memory. *Annual Review of Psychology, 49*(1), 87–115. https://doi.org/10.1146/annurev.psych.49.1.87

Hattie, J. A., & Donoghue, G. M. (2016). Learning strategies: A synthesis and conceptual model. *npj Science of Learning, 1*(1), 1–13. https://doi.org/10.1038/npjscilearn.2016.13

Johnson-Laird, P. N. (2006). *How we reason*. Oxford University Press.

Kearney, A. (2012). Present memories: Indigenous memory constructs and cross-generational knowledge exchange in Northern Australia. In E. Keightley (Ed.), *Time, media, modernity* (pp.165–83). Palgrave.

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

Klingberg, T. (2009). *The overflowing brain: Information overload and the limits of working memory*. Oxford University Press.

Roediger, H. L., & Butler, A. C. (2011). The critical role of retrieval practice in long-term retention. *Trends in Cognitive Sciences, 15*(1), 20–27. https://doi.org/10.1016/j.tics.2010.09.003

Shay, M., & Oliver, R. (2021). *Indigenous education in Australia*. Routledge.

Sweller, J., Van Merrienboer, J. J., & Paas, F. G. (1998). Cognitive architecture and instructional design. *Educational Psychology Review, 10*, 251–296. https://doi.org/10.1023/A:1022193728205

Vosniadou, S. (1992). Knowledge acquisition and conceptual change. *Applied Psychology, 41*(4), 347–357. https://doi.org/10.1111/j.1464-0597.1992.tb00711.x

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