Australian Education Research Organisation

Explainer

Managing cognitive load optimises learning

September 2023

Cognitive overload refers to a state that can happen during learning where students struggle to process and store new information in memory. Teaching that actively manages cognitive load has a positive impact on students' ability to engage with learning tasks and, more importantly, to retain what they have learned as part of those tasks. Cognitive load affects all learners, in all contexts, but can be managed with effective teaching.

This explainer provides a brief introduction to cognitive load, focusing on ways to manage it for effective and efficient learning. Related explainers with similar implications for effective teaching practices and related policies introduce the role of knowledge in the learning process and the positive impact of explicit instruction.

Role of memory in learning

Students learn by using working memory to focus on and process new information, allowing them to connect it to what they already know. Under the right conditions, new information – whether factual, conceptual or procedural – is transferred to long-term memory, where it is stored as mental models that reflect our understanding of the area of learning. Building on the connections within and between these mental models helps students develop a deeper understanding of an area of learning over time. Knowledge stored in long-term memory can be recalled to working memory, where it can be combined and recombined with other new or remembered information to help students generate novel ideas, solve unfamiliar problems and think critically and creatively (Fiorella & Mayer, 2016; Kirschner et al., 2006).

Why managing the load on memory is important

Working memory and long-term memory both play important roles in learning, but they operate in different ways. Working memory is a fast and flexible, but unstable, system that can manipulate information quickly, allowing us to use it at a given time without storing information. Novice learners can experience cognitive overload and have trouble retaining and recalling their learning when the limits of working memory are exceeded. Students may experience cognitive overload when processing too much information at one time, when information is very complex, or when trying to learn in overly distracting learning environments. Long-term memory has vast storage capacity, but to use it most effectively, information needs to be transferred between working and long-term memory bit by bit, and retrieved at regular intervals for more secure storage over time.

Working memory is always limited (Craik & Lockhart, 1972; Kirschner & Hendrick, 2020), and some students will experience additional limitations in using working memory, and in processing information (Melby-Lervåg et al., 2016). This makes the management of cognitive load important both for equitable access to educational opportunity, and for supporting excellence in learning achievement.

Promoting the management of cognitive load for optimal learning

The evidence about how students learn provides a clear direction for the development of curriculum, instructional materials, practice guidance and policies that support effective pedagogical approaches. Without consistent and coherent guidance, schools and teachers are influenced by a range of approaches that may not be based on strong evidence.

Learning is optimised when policy and guidance promotes and supports the following practices:

» Provide small amounts of new information to support retention

Teaching that manages cognitive load begins with a clear explanation of what students are expected to learn, and new material is broken up into small, manageable chunks with well-defined goals (Rosenshine, 2012). Information required to complete each learning task is presented in one place and at one time. Information not directly related to the task is excluded to prevent occupying limited space in working memory (Sweller et al., 1998).

» Guide and support learning to help students focus on the essential new information

Students can experience cognitive overload when the task is too conceptually difficult for their current level of knowledge and skills (Centre for Education Statistics and Evaluation [CESE], 2017). 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). Sequencing content logically from simple to complex and providing concrete examples of abstract content can also help limit complexity that may otherwise contribute to cognitive load.

» Draw on prior knowledge and connect new information gradually to optimise the limitations of working memory

Presenting new information gradually so students can store and then retrieve information from long-term memory as they expand on their learning is one of the ways teachers reduce the burden on working memory. A student might initially need nearly all their working memory (several chunks) to represent the idea of an atom, leaving no further room to learn about related topics like an atom's structure or properties. However, once learned and accessed from long-term memory, the complex idea of the atom will only take up one chunk, leaving the rest of their working memory free to build on that knowledge.

» Prevent misconceptions by checking for understanding throughout learning

Long-term memories are somewhat stable and tend to be recalled or retrieved in the same way they were transferred from working memory. This makes it important to identify and address misunderstandings as they develop, before they are stored in long-term memory. When teachers sequence the information in learning tasks logically, check for understanding frequently, and structure tasks to prevent and correct common errors or misconceptions, they can help students transfer accurate information to long-term memory, avoid misconceptions being formed, and connect their learning meaningfully for deeper understanding of the learning area (Rosenshine, 2012).

» Space learning to allow working memory to rest, and prompt retrieval to allow long-term memory to strengthen

Teachers can support students' ability to retain and apply learning with spaced and varied opportunities to retrieve, review and practise what they've learned. Spacing out learning and providing breaks can account for the increasing limitations of working memory that follow a period of focused effort. When prompted to retrieve what they've learned from memory after a break, students form stronger connections in memory. By practising in varied ways, new and unique connections in memory are formed, making it easier to recall relevant knowledge when prompted by a wider range of possible applications in the future (Perry et al., 2021; Rosenshine, 2012).

» Avoid unstructured, student-led approaches for novice learners

School-aged students are regularly required to learn new information and can be considered novices at that point in their learning. The brain of a novice processes information differently from the brain of an expert, even when they are exposed to the same information. Novice learners need more time and guidance than experts because novices first need to build the mental models of understanding in long-term memory that experts already have (Kalyuga, 2007). Learning tasks that are not well-structured and guided expose students to information not directly relevant to the task at hand, which can overload working memory (Sweller, 2016).

When novices 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. Students may finish tasks without actually connecting and transferring information within the task to long-term memory (CESE, 2017). The high cognitive load associated with minimally guided tasks can lead to gaps in learning and misconceptions that need to be corrected. For example, students asked to collate information 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. Once students have mastered the relevant background knowledge of a subject, they can apply and extend their learning effectively through increasingly independent tasks and structured inquiry (Fiorella & Mayer, 2016; Hattie, 2023; Martin & Evans, 2018).

» Provide a learning-focused environment to prevent distractions that contribute to cognitive load

Visual and auditory distractions may occupy the mental space of students' working memory that they need to focus on learning content. Additionally, learning environments with unclear behavioural expectations and inconsistent rules and routines can pull students' focus away from their learning (Alter & Haydon, 2017). 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. With their focus on learning, this aids effective transfer and retention in long-term memory (Chaffee et al., 2017; Simonsen et al., 2008).

Implications for policymakers

- When students experience cognitive overload they have difficulty processing, retaining, recalling and applying their learning.
- Unstructured, self-led learning is ineffective for school students encountering new information because they need guidance to master the relevant background knowledge of a subject before they can engage effectively in independent practice.
- Policies and programs that advocate for well-sequenced, spaced explicit instruction and learning-focused environments can facilitate improved learning outcomes.

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ISBN 978-1-923066-14-4 (online) |