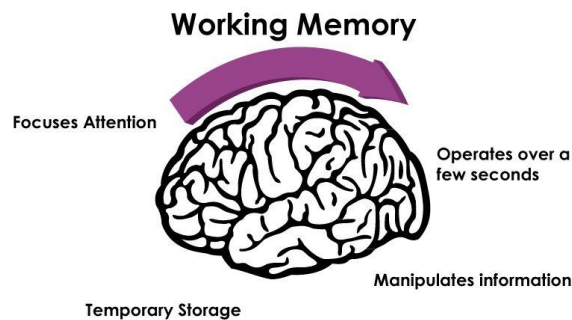# Working Memory and Cognitive Load

What is **working memory**?

Working memory is the term used to describe our ability to hold information in our short-term memory and work with it over a short period of time e.g. when we do mental maths or take directions from someone. It is a temporary cognitive system which operates in seconds.

Working memory is limited. We can only remember so much before our brain becomes overloaded. We must continue to pay attention to the process all the time we are doing it or else we lose where we're up to. This can happen:

- If we get distracted by something (a thought, a noise, a visual, another task)
- If the task is too big (e.g. the sum is too hard to do in your head)
- If the task is too demanding (e.g. the directions you're listening to have ten parts.)

Once we lose our way and the information disappears, we have to start all over again. In the classroom this means that the teacher needs to give the instructions again or have a visual/ model where the child can see it – they won't be able to recover the instructions from their memory.

Working memory capacity can vary between people and increases during childhood. In a primary class you could have some children with a working memory capacity equivalent to a child three years younger, and some with a capacity equivalent to a child three years older.

Many classroom acts such as reading and writing require a lot of working memory. Some children will be working at capacity, which is when they make mistakes. It's hard to remember the sentence they want to write, the order of words, the spelling and the punctuation.

How might children with poor working memory present?

Children with poor working memory will struggle to remember verbal instructions. They may not start tasks or abandon a task part way through. They may decode a text they're reading, but not remember what it's about, or they may struggle to read it at all. They may appear distractible, have poor attention span, be forgetful and make poor progress. When taking a

message or running an errand, they may go to the right place but forget what they were supposed to say/ do.

Children with poor working memory tend to be well behaved in the classroom and have good social skills. Whilst some children with ADHD may have poor working memory as well, they display impulsivity and hyperactivity which children with working memory difficulties alone would not have.

At the moment we have no way to significantly improve working memory capacity, so supporting children with poor working memory is best done by **reducing cognitive load.**

Cognitive Load has been described as;

'The single most important thing for teachers to know.'

What is Cognitive Load theory?

Cognitive load theory is about optimising the brain's working memory in order to maximise the capacity for learning.

We hold new information in our working memory for a short time in order to process and work with it. There is a limit to how much new information we can hold in our working memory (usually about seven things) and we can't work with all of it at once. If we only ask the brain to do those things which are essential for the new bit of learning, it's more likely we will remember it.

Why is cognitive load important to learning?

Learning happens when information transfers from *working memory* and moves into our *long term memory*. We can only hold information in our *working memory* for a few seconds but we can process a lot of learned/ stored information from our *long term memory* at once. The more facts and information you have in your *long term memory*, the more effectively you can use your *working memory*.

If working memory is overloaded, learning slows down or stops. Overload can be too much new information at once, including sensory information such as noise or visual distractions. Imagine working memory as a funnel which information has to pass through in order to reach the huge beaker of long term memory. If you try to tip too much information in at once, the funnel clogs up and the information flows over the sides of it instead of going into the beaker.

How can I use this knowledge to make my lessons better?

There is a lot of evidence to show that pupils learn most effectively when they are given explicit instruction and examples which they then practise and get feedback on. Research has

highlighted a few strategies which reduce demands on the working memory and thus improve learning.

These strategies and examples were summarised by the New South Wales Centre for Education, Statistics and Evaluation[1] as:

1. Tailor lessons according to students' existing knowledge and skill
2. Use lots of worked examples to teach new content/ skills
3. Gradually increase independent problem solving
4. Cut out inessential information
5. Present all essential information together
6. Simplify complex information by presenting it both verbally and visually (dual coding)
7. Encourage students to imagine concepts and procedures they have learned

Taking the funnel metaphor further, if pupils already know a lot about a subject and the new learning is quite simple then the funnel pours easily and you can push new learning faster and add extra information without it clogging up.

If the pupils don't know much about the subject, then you need to optimise working memory by cutting out non-essential information, reducing unnecessary distractions, dual coding, reducing superfluous language, giving lots of worked examples (and leaving those examples where learners can see them), and scaffolding answers until they can do it unaided. This applies to diagrams/ power point as well as speaking and writing.

Planning a lesson using cognitive load theory

In order to plan a lesson, you need to identify how many parts there are to the new learning (how complex it is) AND the learner's prior knowledge.

Let's imagine a lesson in which we want learners to analyse the effect of Maya Angelou's poetic techniques in a particular poem.

Firstly, we would identify what they already know. In this example, we assume they've already learned about general poetic techniques and been introduced to Angelou in previous lessons.

Strategy	Why?
Revise central themes in Angelou's writing. What effect is she trying to have on the listener/ reader? *Leave key words on display.*	The new learning in this lesson is about the poet's techniques. They have not reached mastery of Angelou's themes yet so leaving these in sight reduces cognitive load, freeing working memory for the new learning.
Revise relevant general poetic techniques as a class first and *leave those where the*	As above. Leaving a list of techniques frees up working memory to examine the impact of the poet's writing without having to memorise all

learners can see them e.g. on a prompt sheet on their desk.	the techniques. As the learners do more worked examples of this type in later lessons, you can start to withdraw the techniques crib sheet.
Teacher reads the poem (or plays video), then gives learners a copy to read themselves.	Reading and listening to something unfamiliar at the same time makes greater demands on working memory.
As a class, define any unfamiliar words in the poem. Learners write these on their copy of the poem next to the underlined word being defined.	Learners cannot analyse the language if they are unsure of definitions. Writing definitions on the poem means all essential information is together. This makes it easier to access in the lesson, and easier to visualise and recall later.
Teacher shows some worked examples, identifying quote, technique and effect, *also leaving them visible.* Work through a few examples as a class, in different orders e.g. for some identify 'effect' first, others start with the quote and the rest identify a technique and look for examples of it.	Worked examples are the most effective way to instil new learning. Leaving them as a reference means learners only have to think about the essentials rather than sentence structures etc. As they reach greater levels of proficiency (when it is in their long term memory) this supporting information can be withdrawn.
Provide a table for learners to fill in with 'chosen quote', 'poetic technique' and 'effect' as headings and give individual feedback. Differentiate by giving some learners a table containing the specific quotes to analyse or techniques to look for.	Scaffolding the task means they aren't leaping from worked examples to writing their own sentences, which frees up working memory. Learners who may still struggle are given one or two of the three components to further focus their attention.
Show learners how to write their findings as full sentences with embedded quotes, and *leave examples on the board/ desk.*	Learners can concentrate on the essential information and don't need to be juggling sentence structures.
Ask learners to pick a number of their own examples to write out in full sentences (specific number to be differentiated according to ability.)	They will have all the information needed to complete this in front of them, so working memory is focused on writing.
Ask learners to close their eyes and visualise the headings on the table. Inform them of any mnemonics etc. to assist this.	This will help consolidate learning into long term memory and provide a strategy for recall later.

Research shows that students who are given lots of worked examples learn new information better than those left to work them out alone. Working something out on your own places big demands on working memory, so you may complete it, but you probably won't remember easily how to do it again. In the example above, their working memory only needs to consider the effects of the language in the poem (the identified aim) and doesn't need to juggle definitions, history, themes, spelling and sentence constructions at the same time, as these are given. Eventually, when they have done this a few times (e.g. for different writers) they will be able to do the whole process unaided as the method and desired outcome will be practised and visualised in their long term memory.

Simple things you can do in the classroom which reduce cognitive load:

- Point to the area on the board you want the learners to look at so they're not skimming all the information.
- The more worked examples for new learning, the better.
- Leave instructions, worked examples and vital information where learners can see it.
- Think about which aspects of the lesson will use working memory and reduce all those which are not necessary to the new learning e.g. by giving definitions, sample sentence structures, spellings.
- Reduce superfluous language when instructing. Avoid idiomatic language, or explain what it means.
- Provide tools such as high frequency word mats, personal spelling books, number lines or recording devices so children or teacher/ TA can say the sentence and play it back in order to write it or follow instructions. Ensure they know how to use any learning aids you provide otherwise you are adding to cognitive load not reducing it.
- Don't give extra instructions while students are working. Stop them and get attention first (or better still, make sure they have all the instructions to start with!)
- Keep information together on as few sheets as possible so they're not using working memory to remember where things are/ look around/ organise themselves.
- Use visual and verbal modes together to aid optimising working memory e.g. talk about something using a diagram to represent it (but be careful to avoid speaking whilst they read something, which places a heavy cognitive load.)
- Once students have learned a skill, encourage them to visualise it so that next time it will require less working memory.

- Encourage metacognitive skills. Make sure learners know WHY they are doing a task, how it fits in, how they can remember it later. e.g. when teaching spelling using a multisensory technique, I frequently remind the learner that they can remember it back in the classroom because this is the one they did with glitter/ yellow playdoh etc.
- Have a signal that a child can use if they get 'lost' e.g. an 'I need help' card on the desk.
- Chunk instructions to present parts of the task at a time.
- Ask the child to repeat the instructions back to you if they appear to be struggling and support them if they have forgotten something. Repeat or rephrase, making sure they have a visual and worked example nearby.
- Use task planners.
- Practise visualising sequences e.g. when playing 'I went to the shops and I bought…' encourage the learner to picture the items in a shop or on a shelf. When learning a new sports skill, ask them to close their eyes and encourage them to imagine the steps they need to take to perform that movement.
- Don't introduce too much new learning into a single session.
- Make sure definitions for non-familiar words are included on the materials/ resources.
- Ensure that their working memory is used for what you want them to learn or do and not remembering lots of other things which could actually be provided.
- Reduce unnecessary distractions which can use up working memory: don't keep interrupting learners when working, keep visual displays 'calm', keep noise down and clear visual and physical clutter from the walls but especially around the area where you give the most input/ feedback e.g. don't have fussy displays behind your desk or around the whiteboard.
- Repeat important information.
- Make sure the learners are physically comfortable: allow movement breaks, give sensory toys if they are not distracting, fix wobbly chairs/ tables, make sure it's not too bright/ dark, ensure those who need them have glasses/ coloured overlays/ coloured paper/ wobble cushions and provide texts/ presentations which are clear to avoid visual stress.

Many teachers delivering lessons with reduced cognitive load have noticed not only increased retention/ learning but much better behaviour in class.

<u>*Where can I find out more about Cognitive Load?*</u>

<u>*Publications*</u>

1 [New South Wales Centre for Education, Statistics and Evaluation Guide to Cognitive Load](#)

[Understanding Working Memory: A Classroom Guide by Gathercole & Alloway](#)

<u>*Books*</u>

Busch and Watson, 2019, *The Science of Learning: 77 Studies That Every Teacher Needs To Know*, 1st edition, Routledge

Caglioni, O, 2019, *Dual Coding with Teachers*, John Catt Educational Ltd

Jones, K, 2019, *Retrieval Practice: Research and Resources for Every Classroom*, 1st edition, John Catt Educational Ltd

<u>*Free online course*</u>:

[Cognitive Science for Teachers](#)