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Cognitive Science

Using research to support teaching and learning

Eleanor Jenkins

17th June 15.00-16.00

18th June 14.00-15.00

Cambridge Schools Conference, June 2025
Future-ready: preparing learners to thrive

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Aims

- understand how children process, retain and recall information
- learn strategies to maximise student learning, retention and recall
- discuss the implications of cognitive science for teaching practices
- explore practical applications of cognitive science in the classroom

Cognitive science has provided us with some incredibly useful insights into how pupils learn. As the Education Endowment Foundation say, there is huge value in teachers having working knowledge of these important ideas about how pupils learn.

BUT…

“Principles from cognitive science are neither myths to be discounted, nor silver bullets that directly translate into accelerated progress.”

2021

Education Endowment Foundation

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Key terms

- Working memory
- Long-term memory
- Cognitive load
- Dual coding
- Retrieval practice
- Interleaving
- Spaced practice (also known as distributed practice)
- Knowledge mapping

What are they?

Choose one or two key terms

Write out a definition for the key term(s)

Which do you think are the most effective?

Which do you think are the least effective?

Why do you think this is?

- Retrieval practice
- Highlighting
- Tailoring teaching to pupils' learning styles
- Spaced practice (also known as 'distributed practice')
- Re-reading notes or texts
- Dual coding
- Knowledge mapping
- Interleaving

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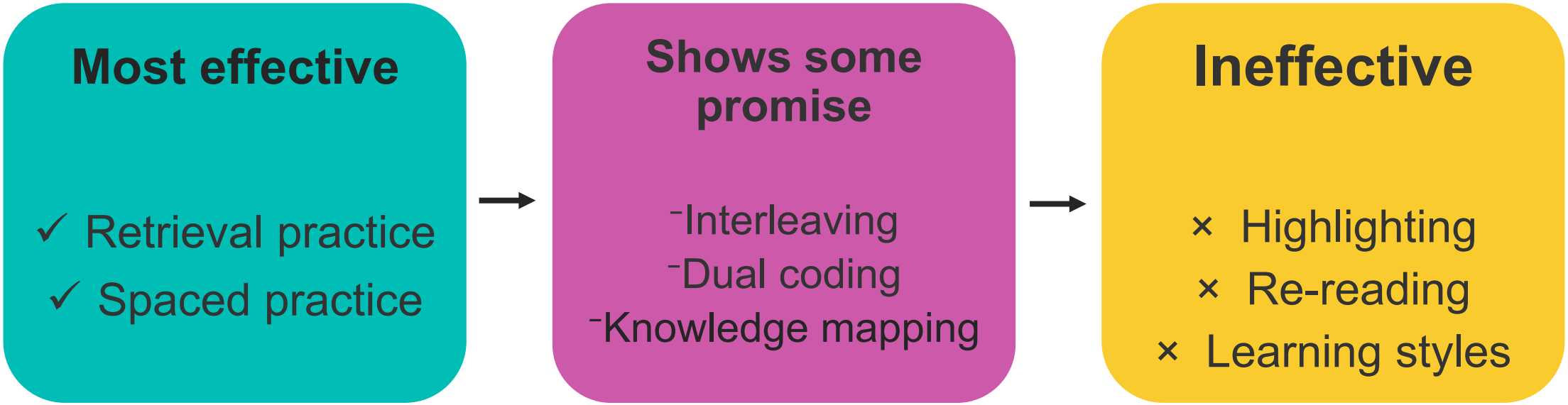
Does it work? What does the research say?



Dunlosky et al (2013), EEF (2021), Willingham (2010)

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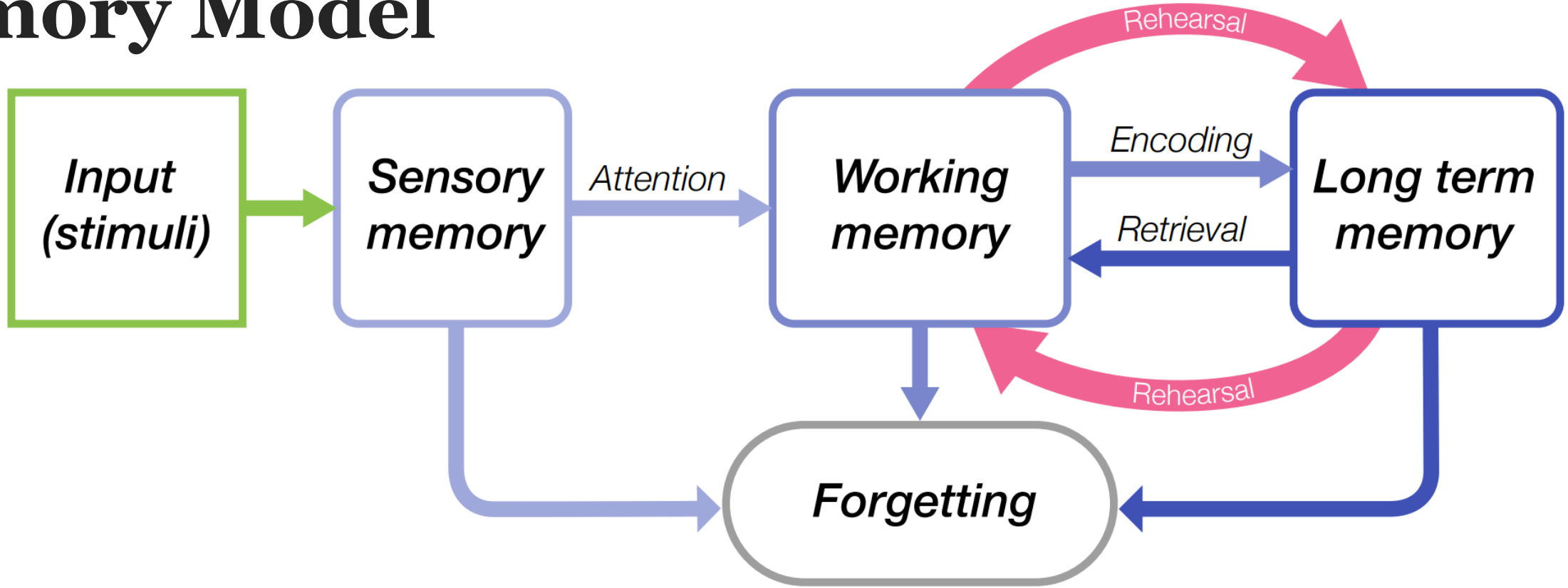
Memory Model



Key Principles to remember:

1. Learning requires information to be committed to long-term memory.
2. Information is processed through the working memory.
3. The working memory has limited capacity and can be overloaded.

Image from the EEF report: Cognitive science approaches in the classroom: a review of the evidence

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Dual coding

Definition:

Using both verbal and non-verbal information (such as words and pictures) to teach concepts.

Caution:

If you add irrelevant illustrations to presentations, they can be a distraction rather than a way of optimising cognitive load.

Early years example: https://www.youtube.com/watch?v=RiaMqgvJuCY

Senior example: https://www.youtube.com/watch?v=iEG82OMp9Nc

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Cognitive Load: what are you thinking about?

- Willingham (2009, p.51) highlights that memory is not a product of what you want to remember or what you try to remember; it's a product of what you think about.

- Time to think: https://www.youtube.com/watch?v=-dtmRmOHK78
- While the pupils are sitting on the carpet listening to their teacher, what do you think they're thinking about?

What does this mean for teaching?

It means we need to focus our teaching on what we want pupils think about.

When planning a lesson, the question we should ask is "What do I want my pupils to think about during this lesson?"

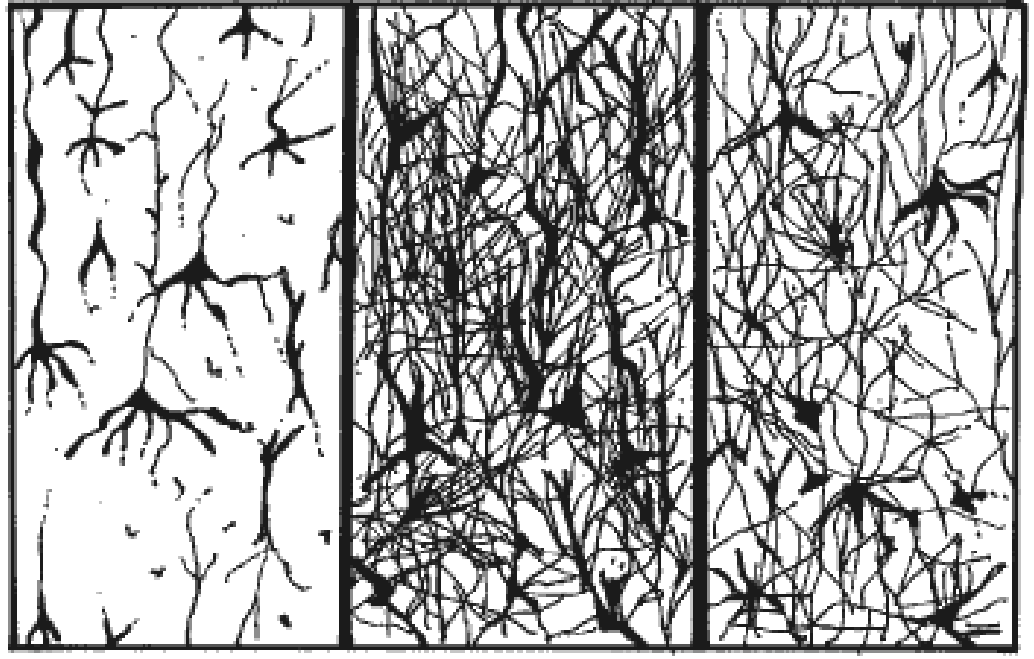
Reflection

1. Recall a recent class you taught. Is the objective you wanted students to reach clear and specific?
2. Can you identify any examples of where you have presented students with extraneous cognitive load?
3. Are there extraneous items you would not want to lose because they serve another purpose? How could you separate them out from key learning materials?

What can teachers do to prevent cognitive overload?

Make your instructions clear and simple	Break longer instructions into smaller parts	Repeat your instructions	Ask pupils to repeat instructions back to you	Give pupils reminders about key information when they are completing independent tasks over longer periods of time
When introducing new content, break complex material into smaller steps	Focus teaching on relevant learning content	Reduce distractions in the classroom	Make content explicit through carefully paced explanation, modelling, and examples	Support pupils to commit some key facts to their long-term memory
Connect new ideas to pupils' prior knowledge	Use worked examples	Represent information both visually and verbally, where it makes sense to do so (this often called "dual coding"	Use collaboration between pupils so they share the demands.	Provide scaffolding

How We Learn



Video: [How We Learn - Synapses and Neural Pathways (youtube.com)]

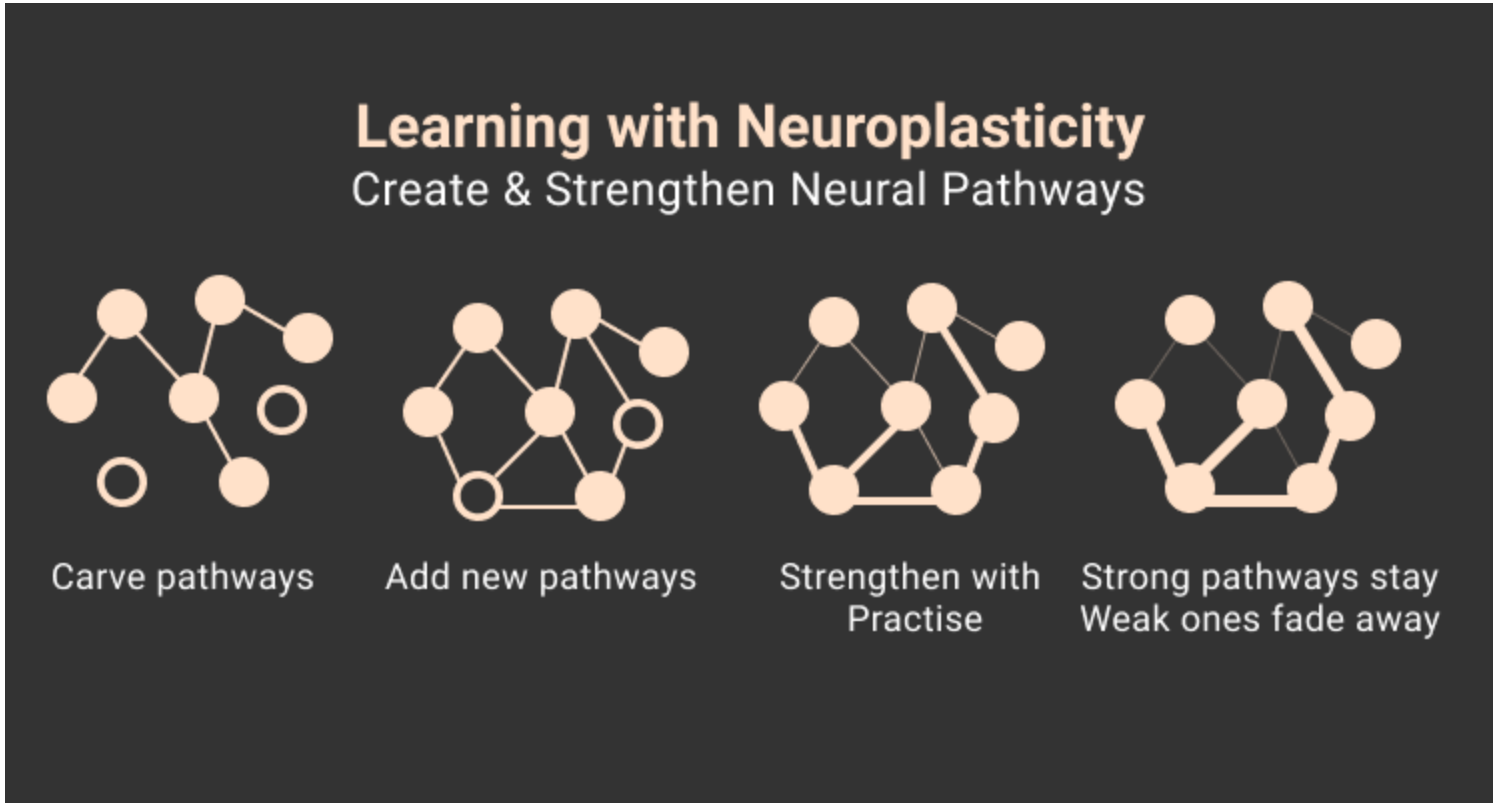


Image credits:
https://www.researchgate.net/publication/252178274_Understanding_Brain_Development_in_Young_Children
https://www.linkedin.com/pulse/learning-create-strengthen-neural-pathways-kamakshi-madankumar/

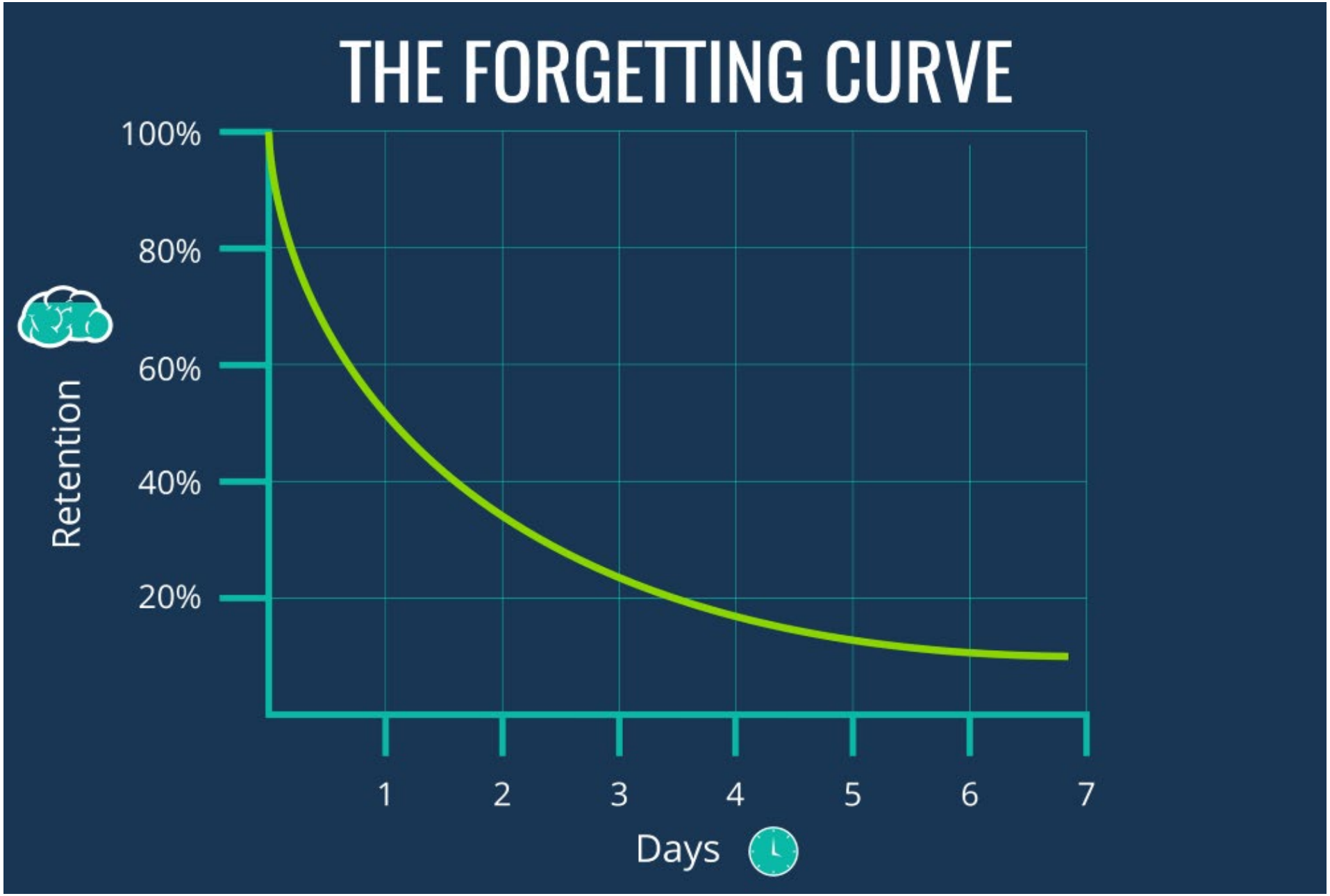


Image credit: https://elearningindustry.com/forgetting-curve-combat

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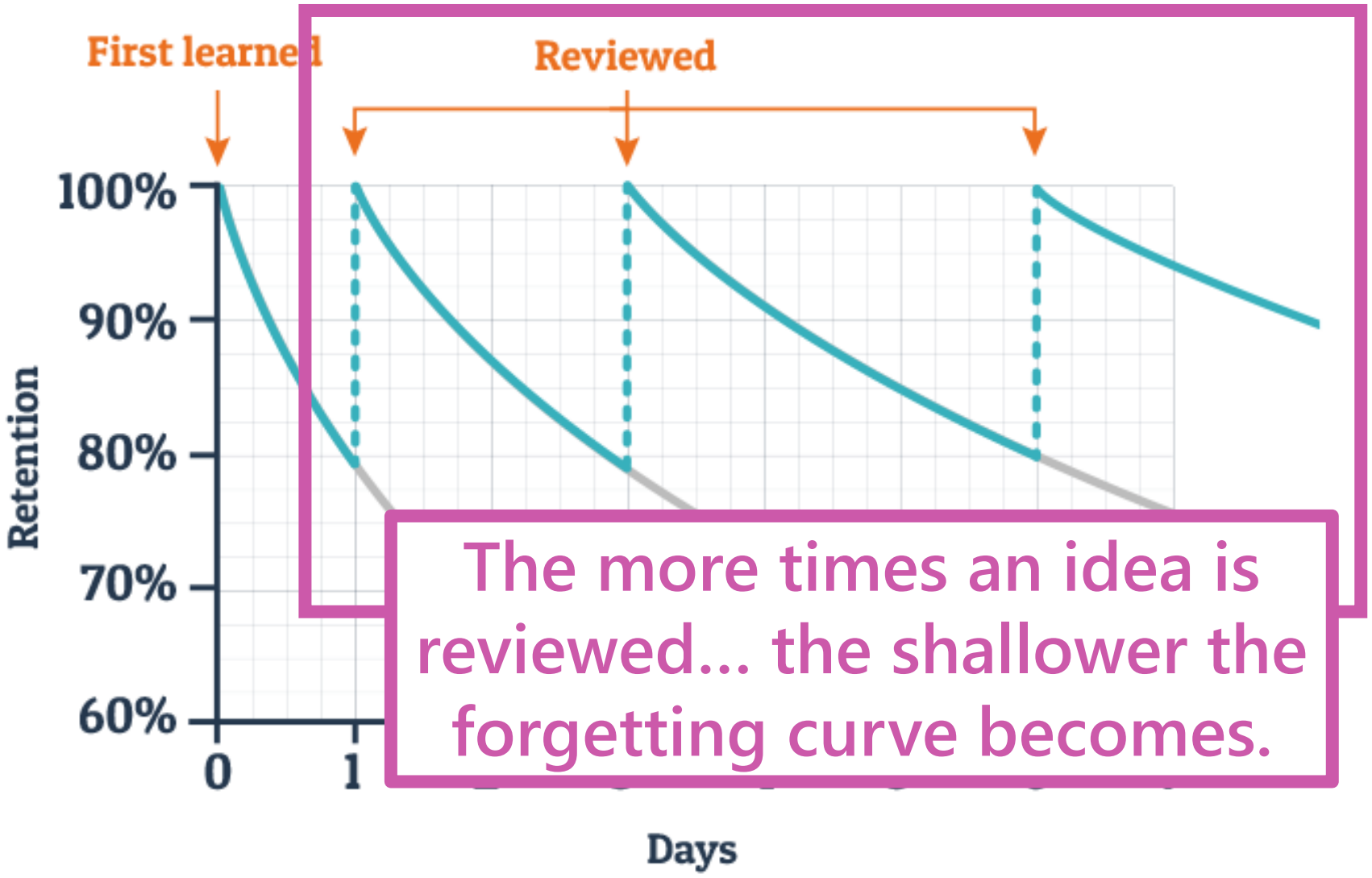
Time to think...

If a pupil can demonstrate a new skill on the day it was taught, but not two weeks later, did they 'learn' it, or not?

Learning involves a **lasting** change in pupils' capabilities or understanding. That's why teaching isn't just about helping pupils to learn new knowledge and skills. It's also about helping pupils not to forget what they've learned

Typical Forgetting Curve for Newly Learned Information



This is why students come back a week later and cannot remember key ideas from the last lesson.

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What is the best way to ‘review’ an idea?

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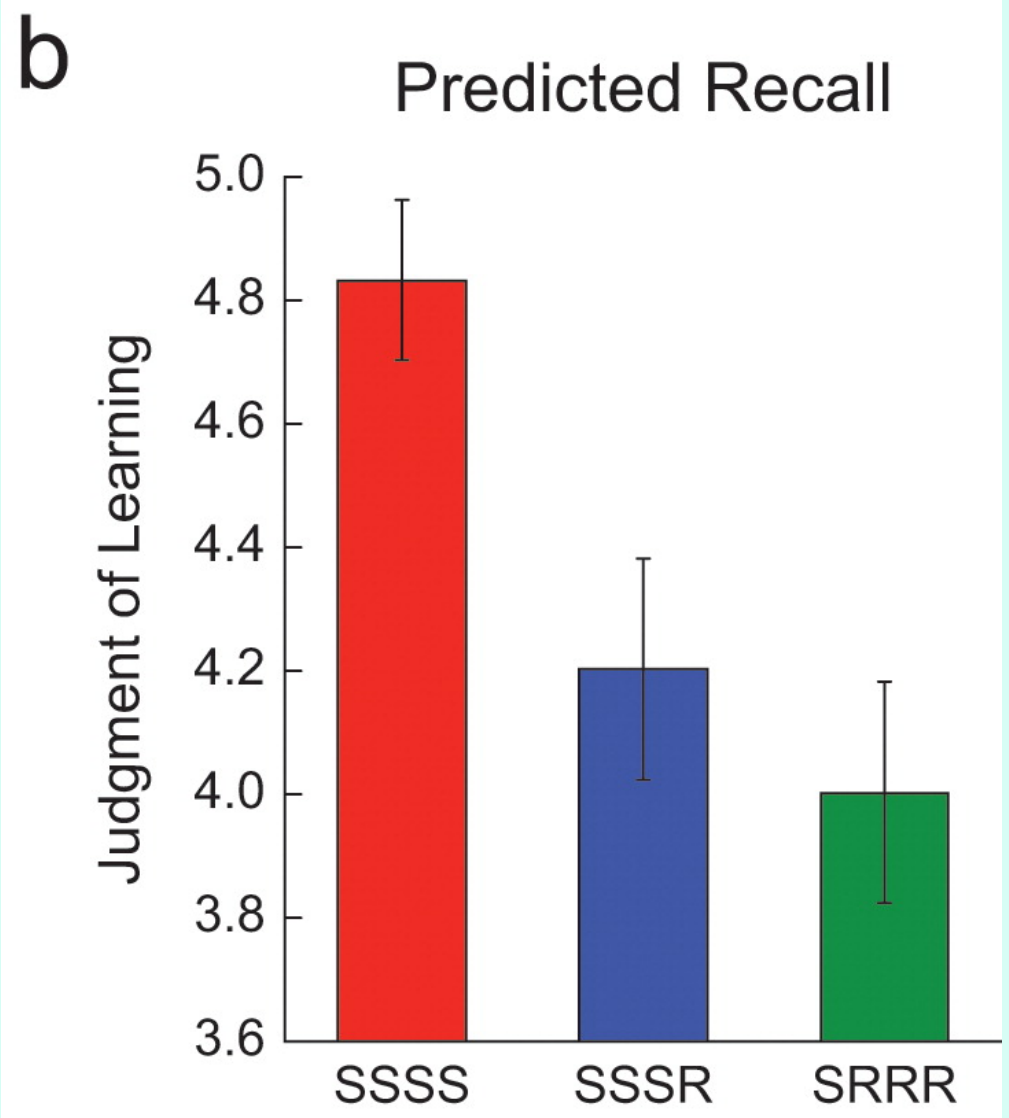
S = study (e.g. re-reading)

R = retrieval

What is retrieval?

It is actively attempting to get the idea from your brain. Saying the answer out loud. Writing it down. Explaining it to someone etc.



The data presented in these graphs are adapted from Experiment 2 of Roediger and Karpicke (2006b) and published in Karpicke, J. D. (2012). Retrieval-Based Learning: Active Retrieval Promotes Meaningful Learning.

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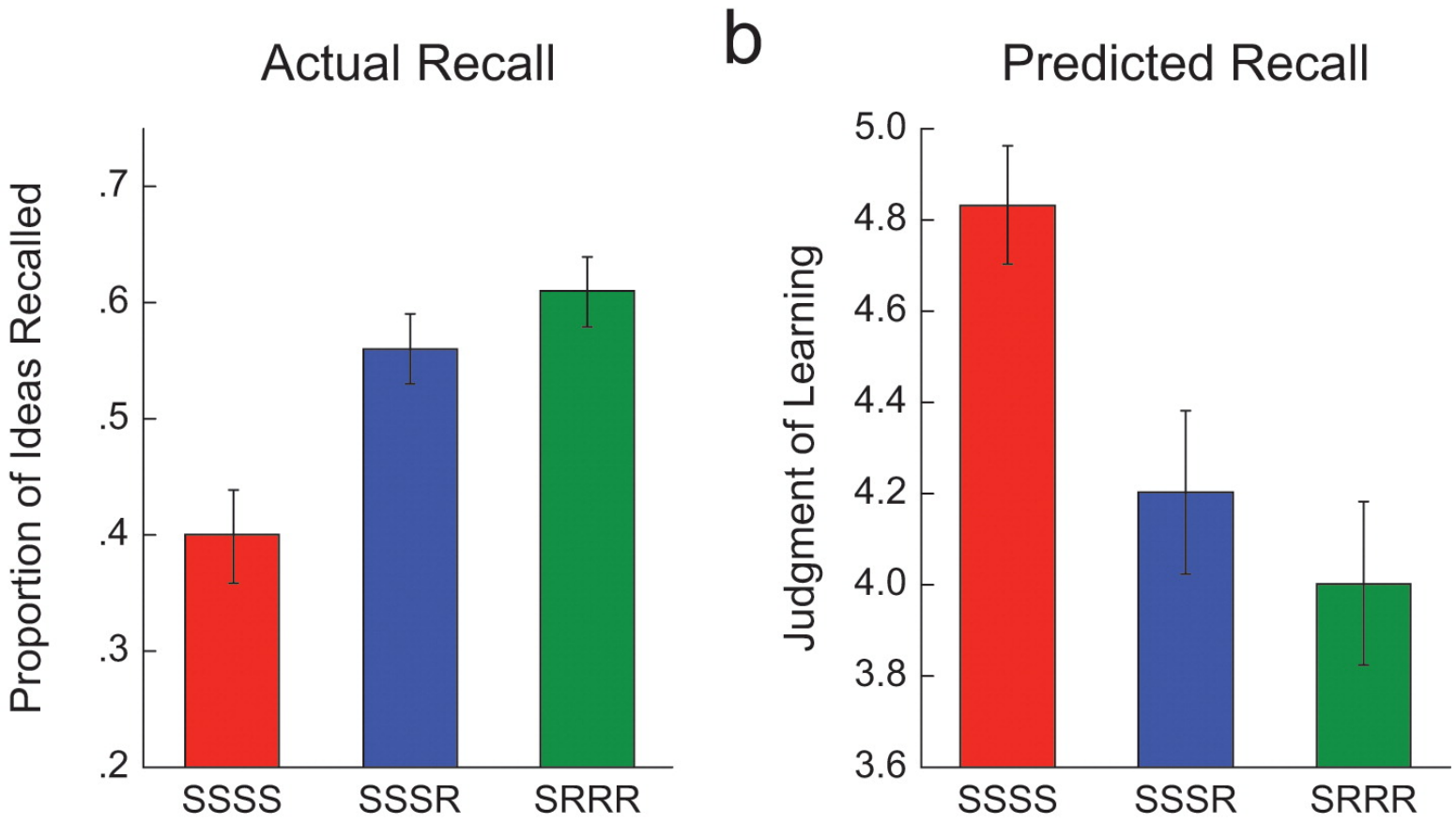

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Learning techniques

This is something that can be helpful for teachers to be aware of, but is also something that can be shared with students to help them understand how best to revise.

Table 2: Effectiveness of ten learning techniques, from Dunlosky et al (2013)

High utility	**Practice testing** Self-testing or taking practice tests on material to be learned
	Distributed ('spaced') practice Implementing a schedule of practice that spreads out study activities over time
Moderate utility	**Elaborative interrogation** Generating an explanation for why an explicitly stated fact or concept is true
	Self-explanation Explaining how new information is related to known information, or explaining steps taken during problem solving
	Interleaved practice Implementing a schedule of practice that mixes different kinds of problems, or a schedule of study that mixes different kinds of material, within a single study session
Low utility	**Summarization** Writing summaries (of various lengths) of to-be-learned texts
	Highlighting Marking potentially important portions of to-be-learned materials while reading
	Keyword mnemonic Using keywords and mental imagery to associate verbal materials
	Imagery use for text learning Attempting to form mental images of text materials while reading or listening
	Rereading Restudying text material again after an initial reading

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What retrieval ideas can you think of?

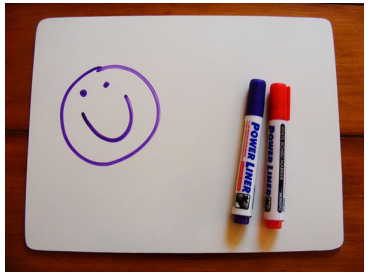
For the classroom…

For independent work

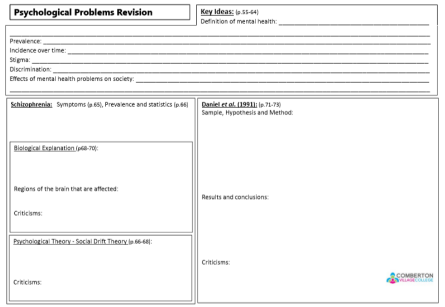
(homework, revision)

Ideas for the classroom

Mini Whiteboards



Retrieval Roulettes



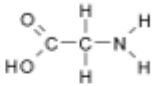
Topic summaries

Plickers

Glossaries

Control group	
Controlled observation	
Correlation	

Dominoes

Amino acids	Which amino acid is this? 
Glycine (Gly)	Which type of reaction breaks down polymer chains?
Hydrolysis	Give an example of a globular protein.

Low stakes recap questions

Cell Structure (page 11)	
Name something a plant cell has that an animal cell does not have	
Name something that an animal cell and a plant cell both have	
Name something that a bacterial cell has that a plant cell does not have	
What is the function of the nucleus?	
What is the role of cytoplasm?	

Quizizz

Challenge grids

(last week, last month, last year)

Exit Tickets

Kahoot!

Whatever you choose:

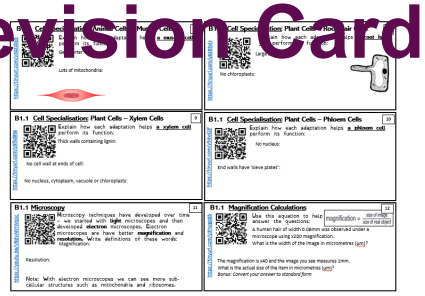
- **All students** should be doing it (not selecting one student to answer)
- **Feedback** is important (the right answers, the best answers, checking own answers against notes etc).
- **Low stakes** is best (no recording of marks) – it is a **learning** tool not an **assessment** tool.
- Should be **effortful!**

Ideas for independent work

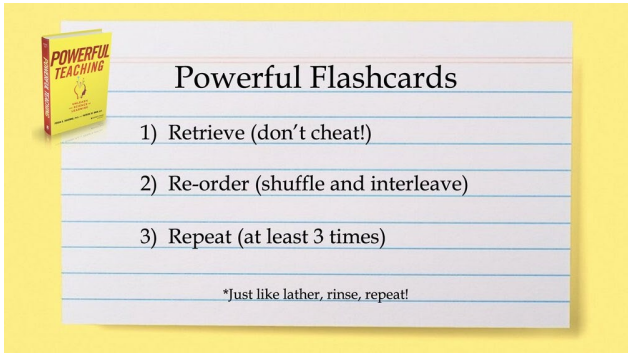
Verbal strategies

Describe a theory, study or concept to a friend or parent.
Get a parent/friend to quiz you.

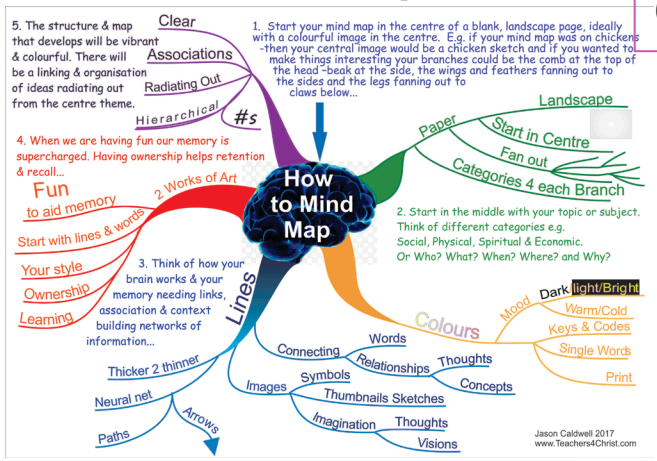
Revision Cards



Create your own revision/flash Cards

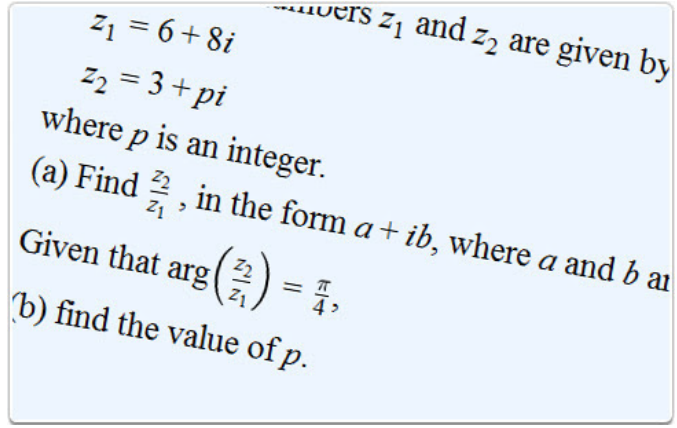


Mind Maps



Brain dump: use a blank sheet of paper and write down as much as you can on a topic

Practice exam questions



$z_1 = 6 + 8i$

$z_2 = 3 + pi$

where p is an integer.

(a) Find $\frac{z_2}{z_1}$, in the form $a + ib$, where a and b a

Given that $\arg\left(\frac{z_2}{z_1}\right) = \frac{\pi}{4}$,

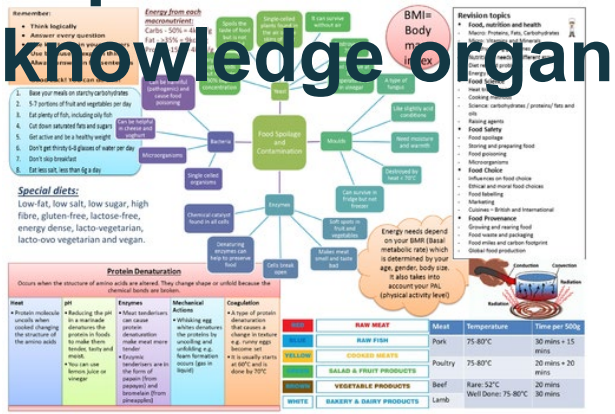
(b) find the value of p.

Glossaries

Control group	
Controlled observation	
Correlation	

Write your own exam style questions

Topic summaries/ knowledge organisers



Involve parents!

Can we give parents resources (e.g. Q+A) and engage them to help? (EEF, 2018 says 2-3 months positive impact!)

Online revision quizzes

Lots available online for example

- Seneca Learn
- Quizlet
- Microsoft Forms
- Quizziz
- BBC Bitesize

Interleaving

- **What is it?** A learning strategy that involves switching between different topics or subjects (as opposed to blocked learning which involves covering one distinct concept at a time).
- https://youtu.be/Rqs2IjX86Is?t=94 (from 1.36)
- **How does it work?** This can help students to see links and similarities between different ideas and concepts and can improve long-term learning. It might work because it helps students learn to distinguish between concepts and learn when to apply which strategy.
- **What shouldn't you do?** It's not worth interleaving completely unrelated material from different subjects.
- **How can you apply this in the classroom?** Mix up questions you give students so they are not all testing one concept (this can also help spaced learning). Ask students to explain similarities and differences between different concepts.
- **Further info:** https://www.the-learning-agency-lab.com/science-of-learning-research-meets-practice.html#

Spaced/ distributed practice

What is it? Space out your studying over time.

Five hours of revision spread out over two weeks is better than five hours all at once.

Students should review information after each class. After they review the information from the most recent class they should go back and study older information too.

Activities within the classroom can be about previous topics. Homework can also be on something that has been studied previously. The teacher should regularly revisit previous content.

Two ways to lose the power of a good theory

Misunderstand an important part of the theory

"Mr Bell has heard a lot about dual coding— and that learning can be enhanced by pictorial representations alongside information. He fills all of his classroom slides with quirky illustrations that he hopes will make the learning memorable. Unfortunately, the images end up distracting his pupils and increasing their cognitive load meaning that they struggle to remember the content itself".

Fail to target the theory effectively

"Mrs Rushby has heard that worked examples with incorrect information in them has been shown to be an effective way of teaching information while managing cognitive load. When she uses the examples in her Year 7 maths class, most pupils struggle to identify any errors—many of them end up reinforcing rather than addressing misconceptions and only a few of the top attaining pupils in the class respond positively to the task".

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Your Task: training sessions

Important ideas about working and long-term memory

The importance of practice in learning

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Roadblocks

1. “We already test our pupils enough without making them take quizzes and tests all the time.”
2. “I’d like to use worked examples in my lessons because I know they can free up pupils’ working memory. But our current curriculum materials don’t include any, and I just don’t have the time to create them myself.”
3. “I’ve already tried spaced practice. My pupils hated it and so did I. Sometimes they can barely remember what I’ve taught them yesterday, let alone a month ago! It was a total waste of time.”

How would you respond?

Discuss in small groups

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Links to further reading

- Learning Scientists website: The Learning Scientists
- Education Endowment Foundation. 2021. Cognitive science approaches in the classroom: a review of the evidence. Available at: https://educationendowmentfoundation.org.uk/public/files/Publications/Cognitive_science_approaches_in_the_classroom_-_A_review_of_the_evidence.pdf
- Dunlosky, J., Rawson, K., Marsh, E., Nathan M., and Willingham, D. 2013. Improving Students' Learning With Effective Learning Techniques: Promising Directions From Cognitive and Educational Psychology. *Psychological Science in the Public Interest.* 14(1): 4-58. Available at: https://www.academia.edu/13564364/Improving_Students_Learning_With_Effective_Learning_Techniques_Promising_Directions_From_Cognitive_and_Educational_Psychology
- 12 page retrieval practice guide: http://pdf.retrievalpractice.org/RetrievalPracticeGuide.pdf
- Excellent overview (with links to further resources) about the best revision methods: https://www.innerdrive.co.uk/what-are-the-best-ways-to-revise/?utm_content=110221461&utm_medium=social&utm_source=twitter&hss_channel=tw-85885295
- Good book on Retrieval Practice: https://www.johncattbookshop.com/retrieval-practice
- Good blog about facts/myths about retrieval practice (written by the author of the book above): https://lovetoteach87.com/2019/11/24/retrieval-practice-the-myths-versus-reality/
- More techniques for retrieval practice in the classroom: https://teacherhead.com/2019/03/03/10-techniques-for-retrieval-practice/amp/?__twitter_impression=true

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Any questions?

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Your feedback

Please let us know your views on this session

Scan the QR code and share your feedback with us

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Get in touch!

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