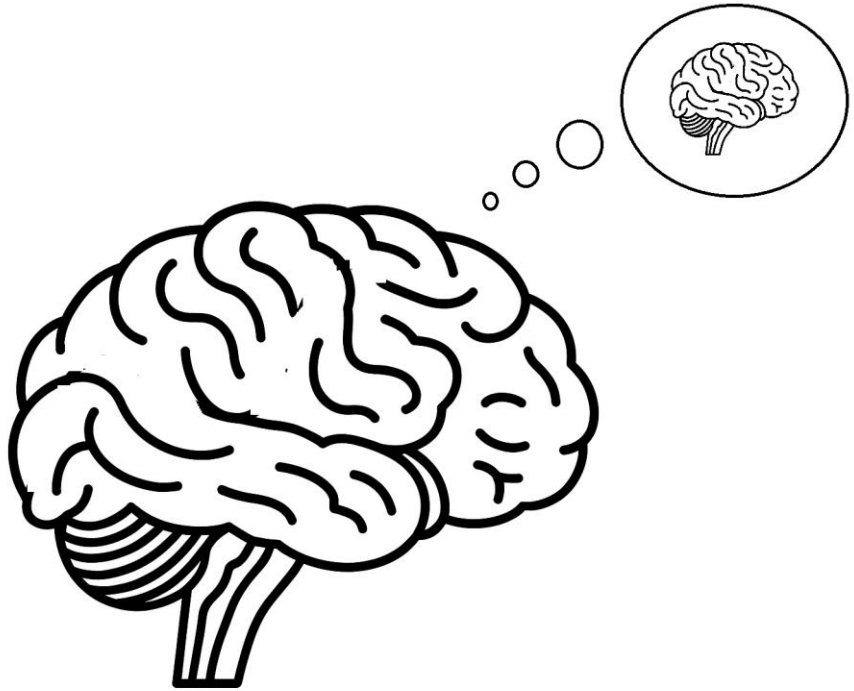
Metacognition:
What it means for students, and why you should teach it



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A little bit about how I got here…

- Taught in the UK
- rED Rugby, and consequences
- Teaching in the US
- rED Denver 2024, rED NYC 2025

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In terms of metacognition…

Why:
… bother?
We've got
enough to do.

What:
what actually
is it?

How:
do you teach it,
and when?

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Why bother with metacognition?

Knowledge → Actions→ Engagement → Learning

- It is clear from research evidence that the quality of teachers' knowledge/beliefs, intentions, and plans with respect to how people learn influences teachers' teaching actions (Kerr 1981; Lawson et al. 2009)…
- … those teaching actions *directly influence students' learning outcomes* (Bereiter and Scardamalia 1989; Hattie 2009; OECD 2005; Rowe 2002).
- Furthermore, the quality of students' knowledge about how they learn influences their engagement with learning, and consequently, their learning achievements (Bandura 2001; Schraw 1998; Schraw and Dennison 1994; Schunk and Zimmerman 1989; Weinstein H. Askell-Williams (&) M. J. Lawson G. Skrzypiec and Mayer 1986).

1. Askell-Williams, H., Lawson, M. J., & Skrzypiec, G. (2012). Scaffolding cognitive and metacognitive strategy instruction in regular class lessons.

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Meta-analysis of 50 studies

- A very positive relationship between teaching metacognition in schools and pupil outcomes, with a mean effect size of 0.69
- Some evidence indicates that teaching metacognition is very helpful for pupils from racial and ethnic minority groups/pupils who present challenging behaviors… and that pupils from low socio-economic groups can match, or even exceed, the academic performance of their peers from higher socio-economic groups when taught metacognitive strategies
- Limited evidence exploring the relationship between metacognition and pupil wellbeing (limited studies)

2. Metacognition in schools: what does the literature suggest about the effectiveness of teaching metacognition in schools?

About us

Who we are, and what we do.

We're an independent charity dedicated to breaking the link between family income and educational achievement. We do this by supporting schools, colleges, and early years settings to improve teaching and learning through better use of evidence.

Toolkit Strands	Cost	Evidence	Impact
Learning styles Unclear impact for very low cost based on insufficient evidence.	£		-
Mastery learning High impact for very low cost based on limited evidence.	£		+5
Mentoring Low impact for moderate cost based on moderate evidence.	£ £ £		+2
Metacognition and self-regulation Very high impact for very low cost based on extensive evidence.	£		+8
One to one tuition High impact for moderate cost based on moderate evidence.	£ £ £		+5
Oral language interventions Very high impact for very low cost based on extensive evidence.	£		+6

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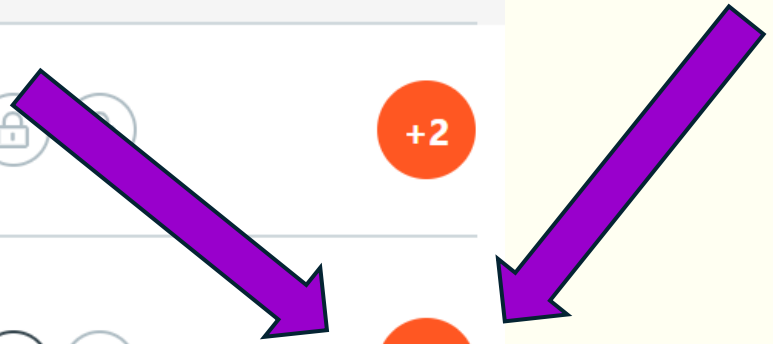

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What is ‘impact’?

- In these reports:

  impact = *number of additional months of progress* made

- Metacognition = **+8** *additional months of progress* ***per year*** *(on average)*

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Education Endowment Foundation

METACOGNITION AND SELF-REGULATED LEARNING

Summary of recommendations

1
Teachers should acquire the professional understanding and skills to develop their pupils' metacognitive knowledge

2
Explicitly teach pupils metacognitive strategies, including how to plan, monitor, and evaluate their learning

3
Model your own thinking to help pupils develop their metacognitive and cognitive skills

4
Set an appropriate level of challenge to develop pupils' self-regulation and metacognition

5
Promote and develop metacognitive talk in the classroom

6
Explicitly teach pupils how to organise and effectively manage their learning independently

7
Schools should support teachers to develop knowledge of these approaches and expect them to be applied appropriately

/metacognition/Summary_of_recommendations_poster_2021-10-27-151056_qiiz_20https://d2tic4wvo1iusb.cloudfront.net/production/eef-guidance-reports21-10-29-074723_miux.pdf?v=1750170084

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Top 3 recommendations from the EEF report

1. Teachers should acquire the professional understanding and skills to develop their pupils' metacognitive knowledge

2. Explicitly teach pupils metacognitive strategies, including how to plan, monitor, and evaluate their learning.

3. Model your own thinking to help pupils develop their metacognitive and cognitive skills.

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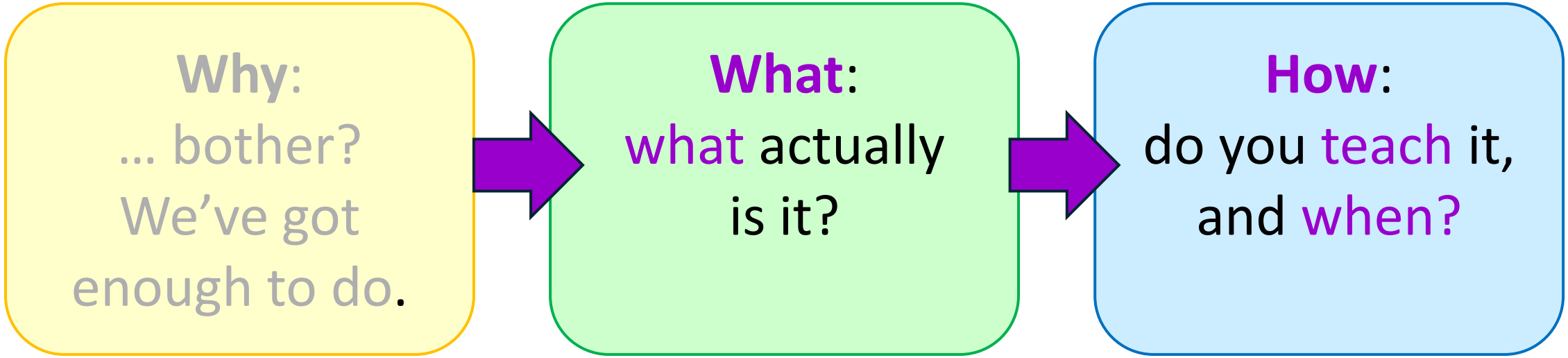
In terms of metacognition…



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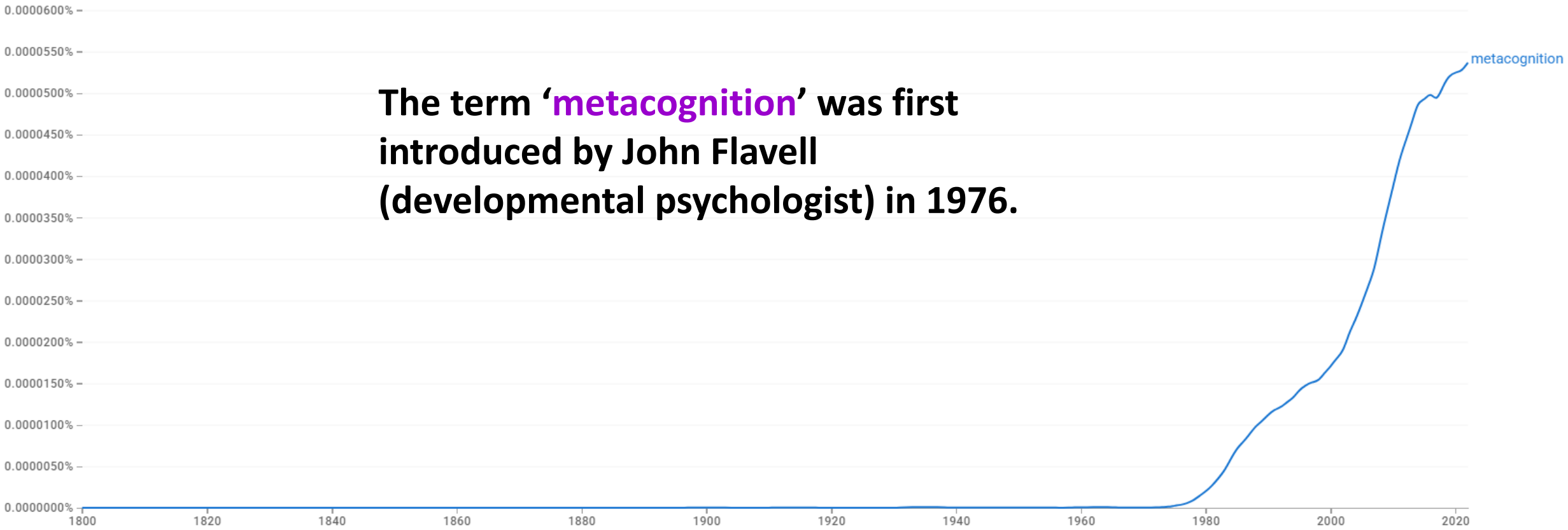
Google Books Ngram Viewer

metacognition

1800 - 2022 | English | Case-Insensitive | Smoothing



The term ‘metacognition’ was first introduced by John Flavell (developmental psychologist) in 1976.

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So where are we now?

- On the sheet… brain dump metacognition

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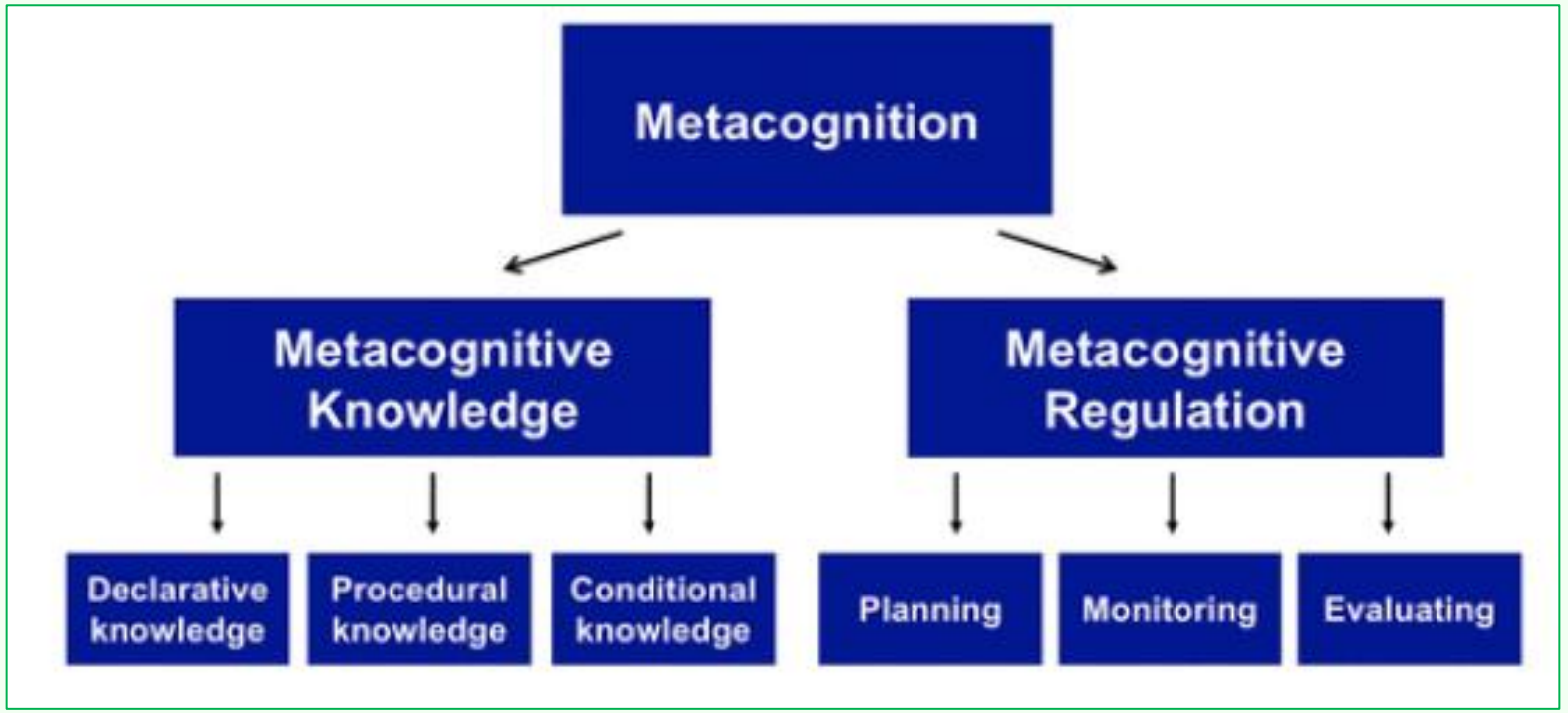
Definitions from the research…

- Can be fuzzy
- Most commonly 'thinking about thinking'
- OECD (*Organisation for Economic Co-operation and Development)* definition:
  - 'Metacognition is second or higher-order thinking process which involves active control over cognitive processes.'
  - Metacognitive strategies are general skills that allow students to manage, direct, regulate, monitor and evaluate their learning.

A very useful distinction



Schraw, G., & Moshman, D. (1995). Metacognitive theories. *Educational psychology review*, *7*, 351-371.

Top 3 recommendations from the EEF report

1. Teachers should acquire the professional understanding and skills to develop their pupils' **metacognitive knowledge.**

2. Explicitly teach pupils metacognitive strategies, including how to **plan, monitor, & evaluate** their learning.

3. Model your own thinking to help pupils develop their metacognitive and cognitive skills.

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What is metacognitive knowledge? Knowledge about what?

- **Declarative knowledge**
- **Procedural knowledge**
- **Conditional knowledge**

What is metacognitive knowledge? Knowledge about what?

- **Declarative knowledge:** knowledge about
  - How people learn (working memory, long-term memory, forgetting…)
  - Yourself as a learner (your work habits, motivation, note-taking skills…)
  - Strategies (retrieval practice, spaced practice, flashcards… and planning!)

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An interlude… lenses to shape our thinking

- To ‘see it like I see it’ is why we are here
- The ‘curse of the expert’ is a real thing
- Novices are not little experts; they learn differently
- Working memory is limited; load it wisely. Long-term memory is infinite
- Learning involves a change to a learner’s long-term memory
- Having a model of memory and learning (Willingham) is extremely helpful if you are trying to learn anything as it helps you choose strategies that are likely to work well.

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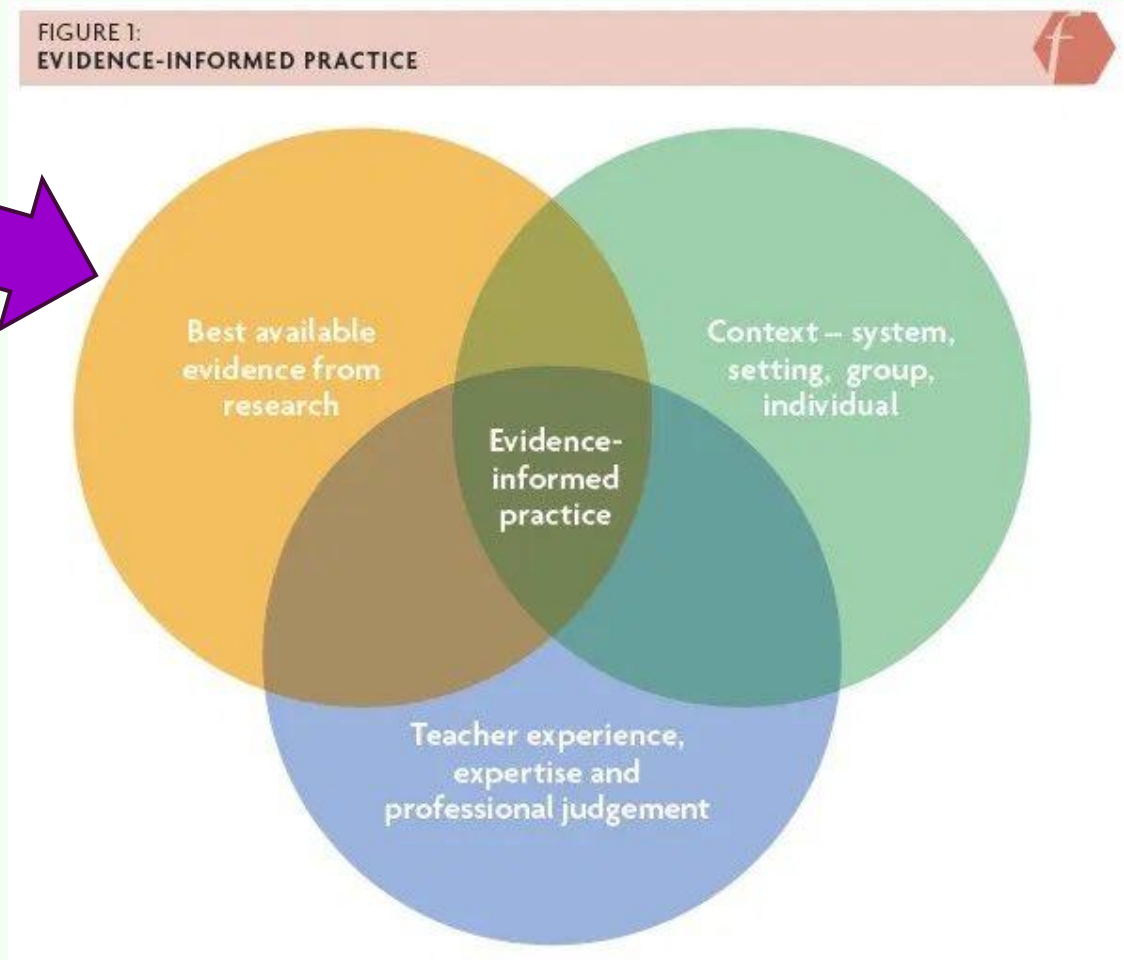
Another useful lens:



https://my.chartered.college/impact_article/addressing-the-challenges-of-using-evidence-in-education/

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- **Conditional knowledge**

What is metacognitive knowledge? Knowledge about what?

- **Declarative knowledge** ✓
- **Procedural knowledge:** knowledge how to best perform strategies
  - Close your notes when doing retrieval practice
  - Space retrieval: 1 day, 1 week, 1 month, 3 months… or similar
  - Shuffle flashcards regularly, remove those the are mastered

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What is metacognitive knowledge? Knowledge about what?

- **Declarative knowledge** ✓
- **Procedural knowledge** ✓
- **Conditional knowledge**

What is metacognitive knowledge? Knowledge about what?

- **Declarative knowledge** ✓
- **Procedural knowledge** ✓
- **Conditional knowledge:** knowledge about when and why to use a strategy
  - Use flashcards over a period of time to learn facts; each time you retrieve it strengthens your memory
  - Start early with retrieval practice for a test; this gives more time to get it into your long-term memory
  - Space your retrieval to give yourself a chance to forget; this will strengthen the memory when you try to retrieve it.

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What is metacognitive knowledge? Knowledge about what?

- **Declarative knowledge** ✓
- **Procedural knowledge** ✓
- **Conditional knowledge** ✓

What is metacognitive regulation?

- Planning on how to obtain your learning objectives/meet your goals
- Monitoring the progress you are making while studying/doing what you need to do
- Evaluating how well you prepared/your overall success.

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Do you need strategies?

- Planning on how to obtain your learning objectives/meet your goals
- Monitoring the progress you are making while studying/doing what you need to do
- Evaluating how well you prepared/your overall success.

- Could you do all of the above without using any metacognitive knowledge?

Metacognitive regulation is better described as:

Using metacognitive knowledge to

- Plan on how to use metacognitive strategies to obtain your learning objectives/meet your goals
- Monitor the progress you are making while using metacognitive strategies to study/do what you need to do
- Evaluate how well you used metacognitive strategies to prepare/achieve your overall success.

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Time for meta-metacognition

- Go back to your brain dump and add/delete…

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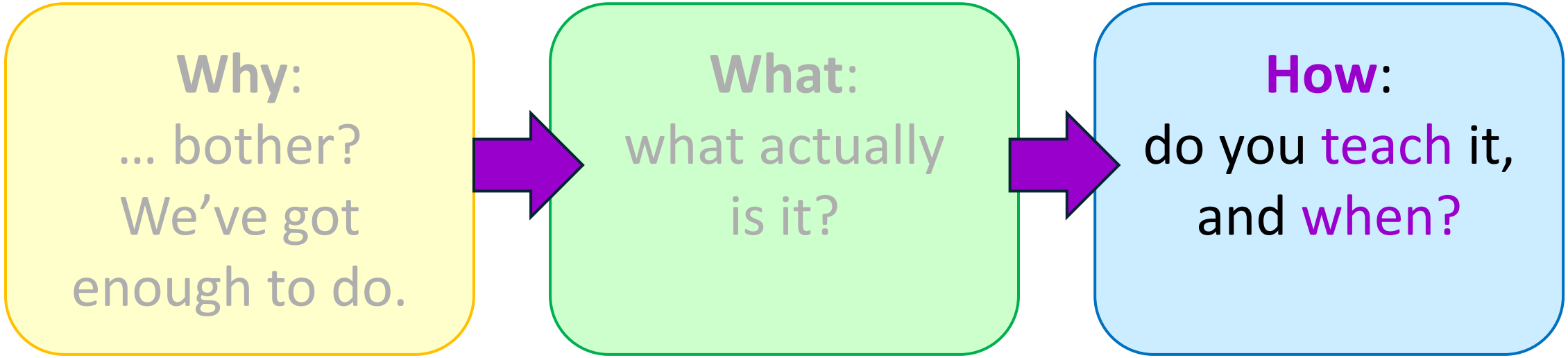
In terms of metacognition…



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We can teach them explicitly…

- **Declarative knowledge:** knowledge about
  - How people learn (working memory, long-term memory, forgetting…)
  - Yourself as a learner (your work habits, motivation, note-taking…)
  - Strategies (retrieval practice, spaced practice, flashcards…)

This.

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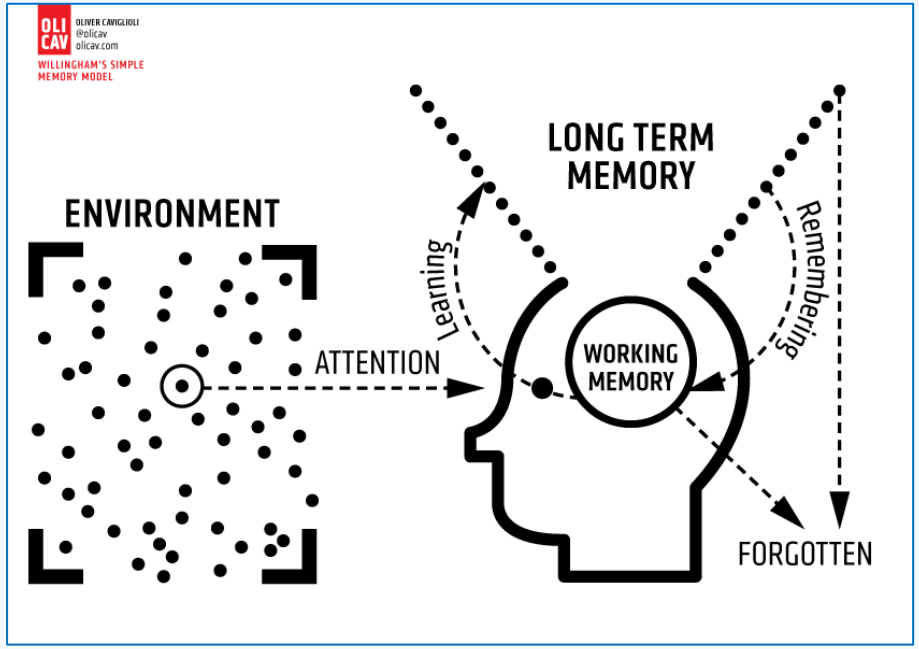
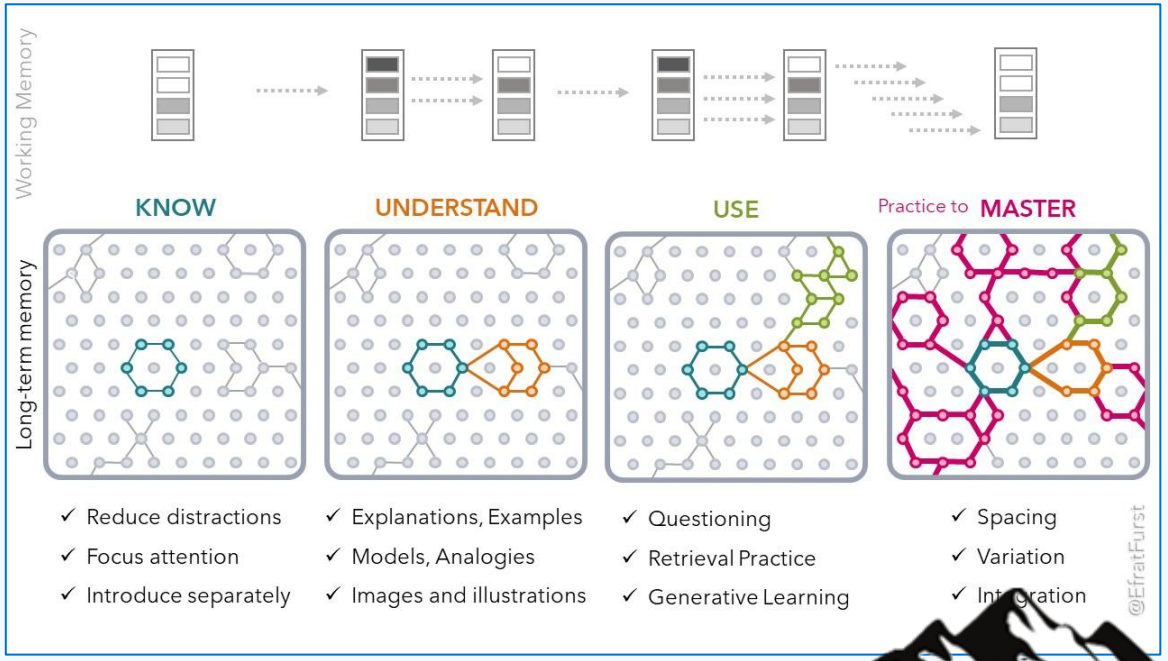
Knowledge of a model of memory, schemas

Teach them about learning, memory and meaning making:

Daniel Willingham's memory model



Efrat Furst's schema diagram



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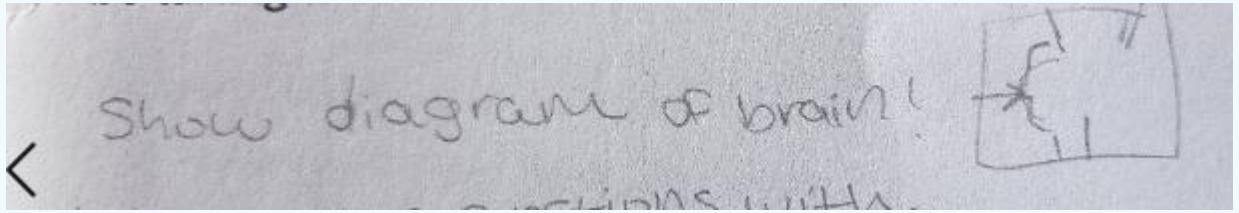
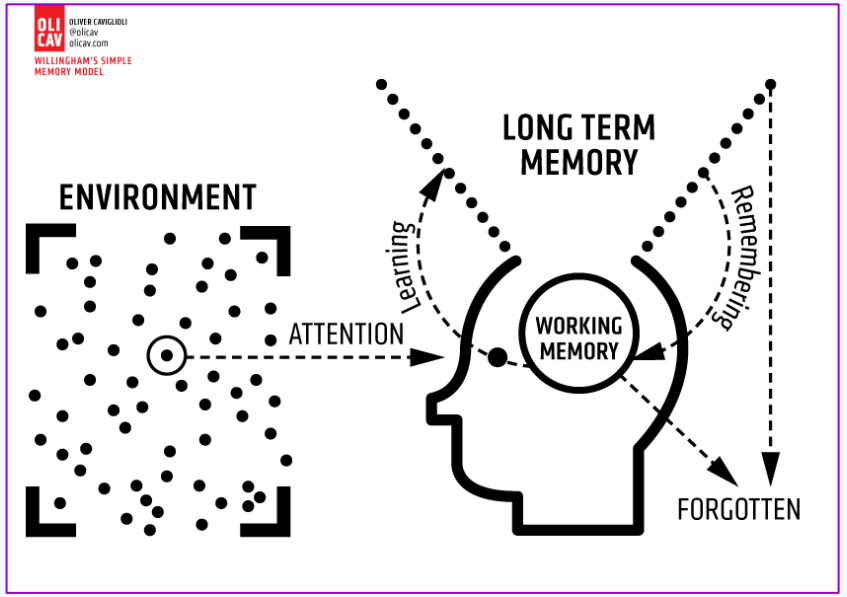
What did the students say I should tell you?

- Explain how learning and memory work





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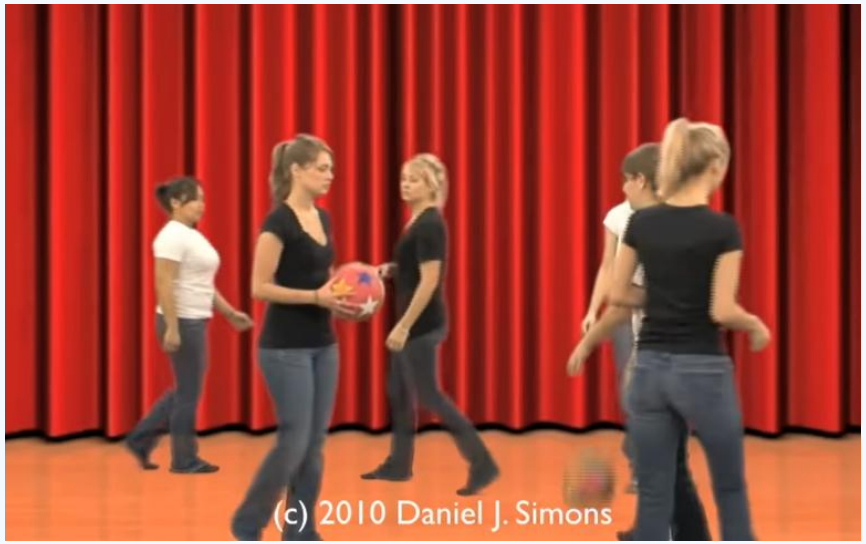
Knowledge of attention and working memory



Count how many times the players wearing white pass the ball

Put the letters of the alphabet in alphabetical order…

A B
H D
R… W…

The letters in the alphabet in alphabetical order

AHRBDWEFLMNSXIJGKQOPCTVYUZ

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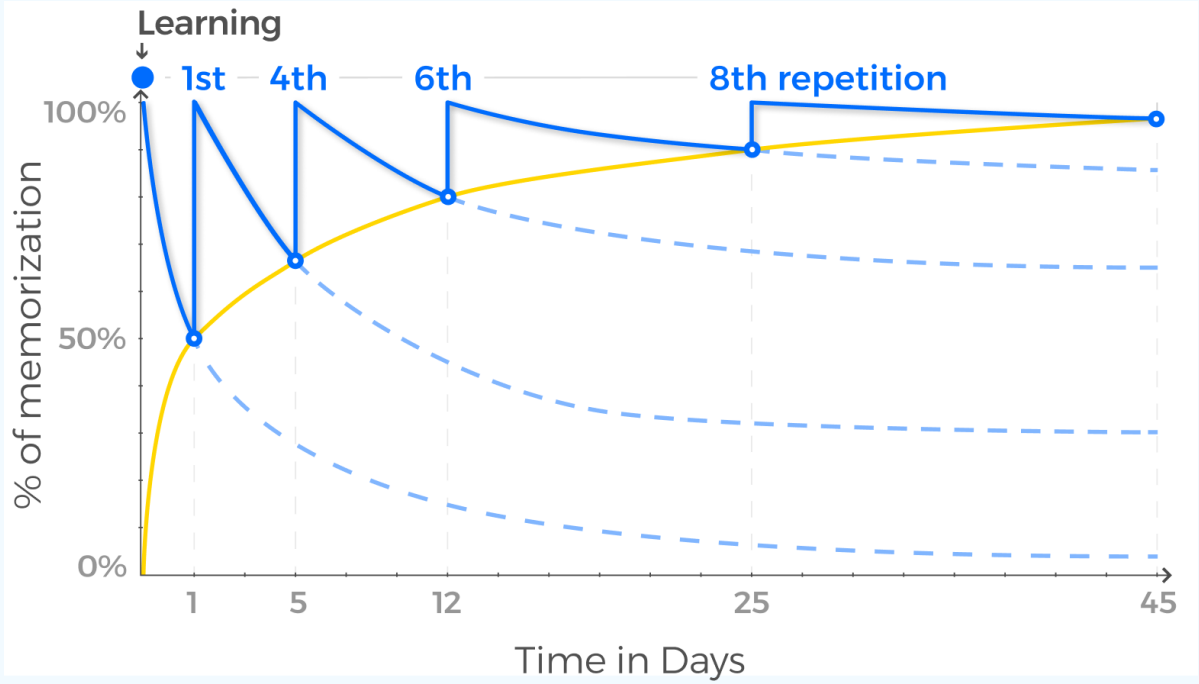
Knowledge of forgetting… and the ‘three’

- Ebbinghaus forgetting curve (1885!)



- The power of three

from The hidden lives of learners
Graham Nuthall

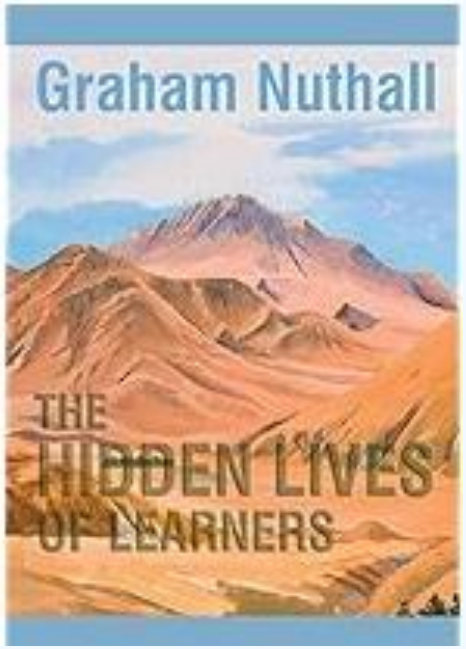


Image: https://www.taalhammer.com/the-forgetting-curve-hermann-ebbinghaus/

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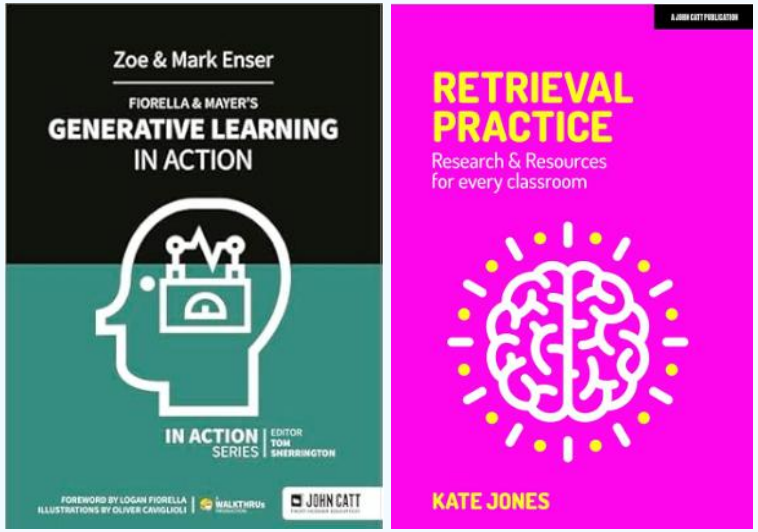
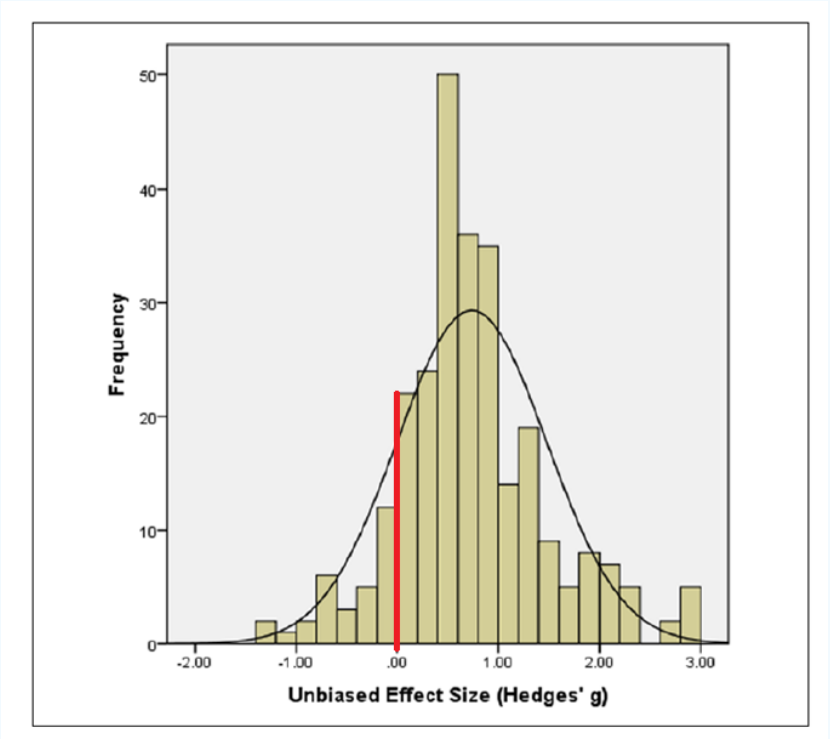
Knowledge of strategies

- Roediger, H.L., III, & Karpicke, J.D. (2006) - the testing effect
- Retrieval practice
- SLOP
- Spaced Practice
- Flashcards
- Self-explanation…

+ non-examples

- Reading notes
- Highlighting
- Cramming





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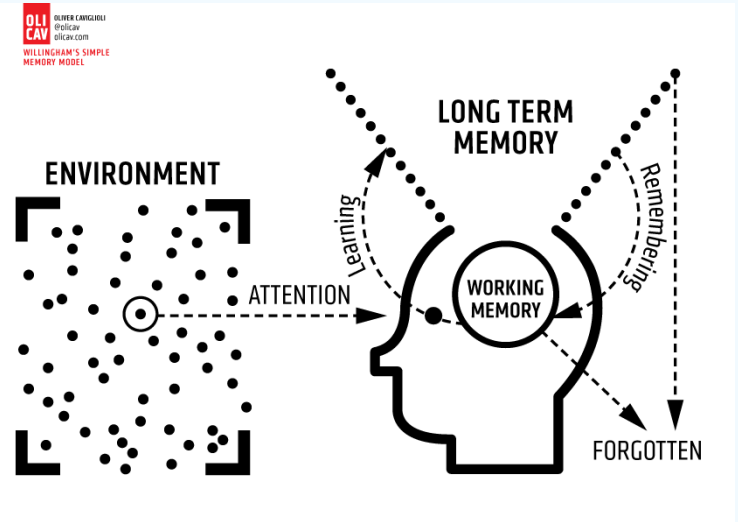
Knowledge of strategies, and why they work

- Retrieval practice… pulling it out of your memory helps you learn
- Spaced practice… leave gaps so there is… forgetting
- Making meaning makes it memorable
- Memorable means connections in your schema



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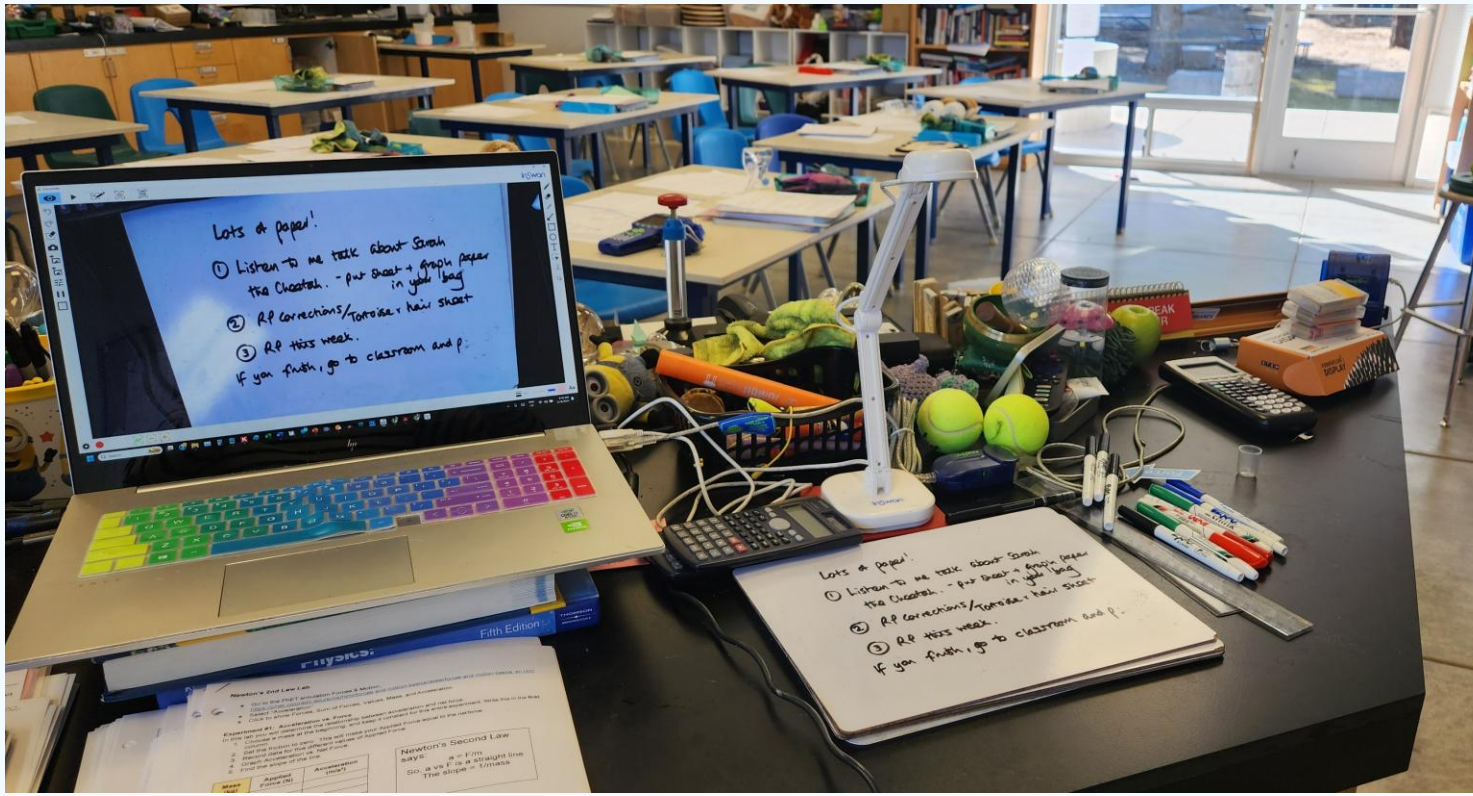
Knowledge of how to best use strategies

- Make my thinking explicit using a document camera
- and it helps their working memory



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Knowledge of how, why, when

Modelling by :

- Retrieval practice = weekly review quizzes
- Questions that:
  - are spaced: last lesson, last week, a long time ago
  - get progressively harder/more abstract/unfamiliar contexts/connecting topics…
- Reminding them why we're doing more retrieval practice (SLOP)
- Modeling making thinking explicit by talking through it in real time (cognitive apprenticeship)

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- repetition is the most valuable strategy

SLOP- Active recall

•Talk about the necessity of SLOPS

• 3x to get into long term memory

SLOP

SLOP

the whole idea of SLOP

-Emphasize different kinds of retrieval practice, most other teachers don't do it

Retreival practice - always revisiting topics to keep t
on the brain

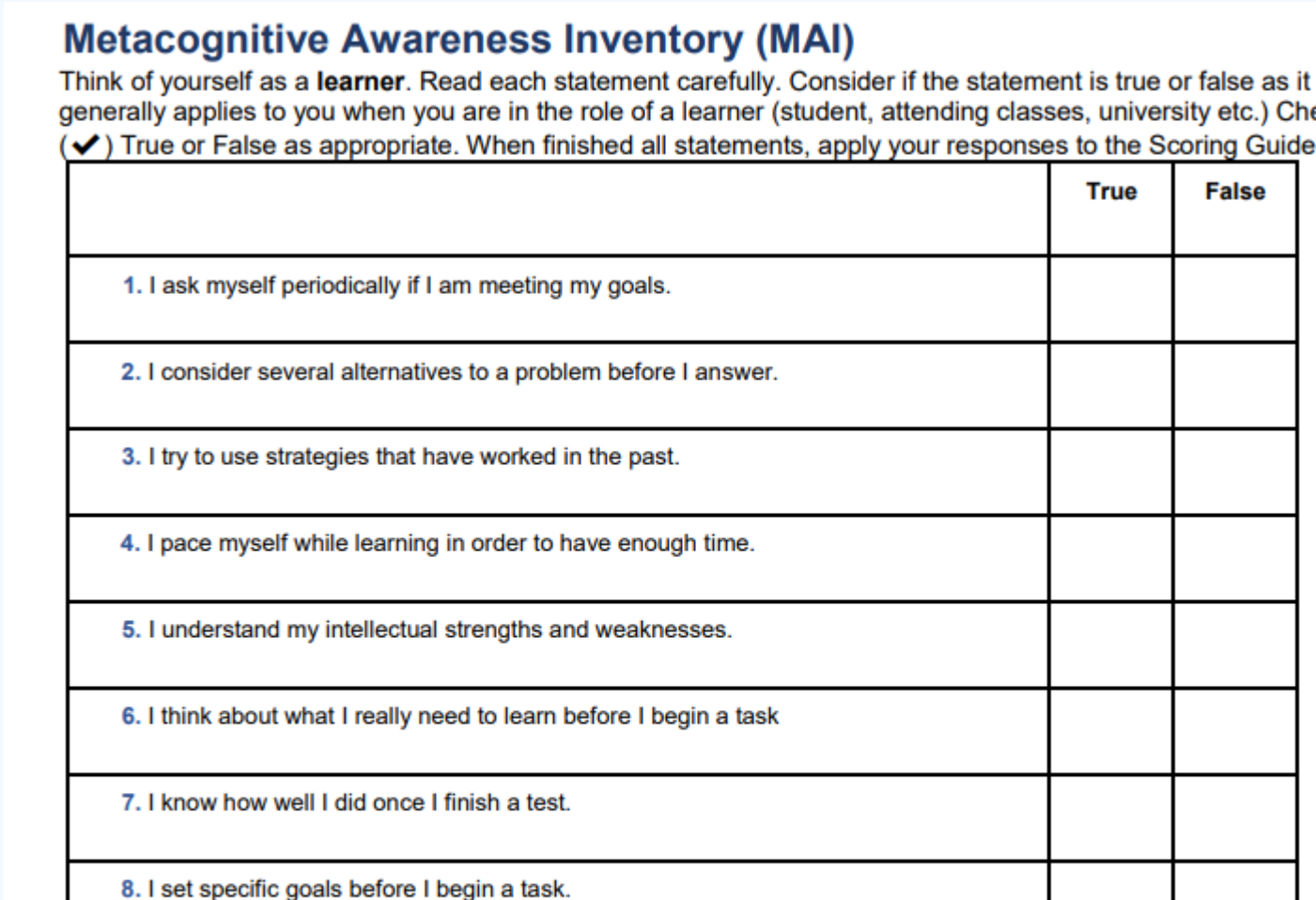
SLOP

SLOP converts what you lear
term to long term memory

Repetition!!!!

Knowledge of yourself as a learner…

- Self-report using the Metacognitive Awareness Inventory (MAI)
- Or discussion with groups…
- … with individuals



Metacognitive Awareness Inventory (MAI)

Think of yourself as a **learner**. Read each statement carefully. Consider if the statement is true or false as it generally applies to you when you are in the role of a learner (student, attending classes, university etc.) Che (✔) True or False as appropriate. When finished all statements, apply your responses to the Scoring Guide

	True	False
1. I ask myself periodically if I am meeting my goals.		
2. I consider several alternatives to a problem before I answer.		
3. I try to use strategies that have worked in the past.		
4. I pace myself while learning in order to have enough time.		
5. I understand my intellectual strengths and weaknesses.		
6. I think about what I really need to learn before I begin a task		
7. I know how well I did once I finish a test.		
8. I set specific goals before I begin a task.		

Metacognitive regulation WITH strategies…

- Planning
- Monitoring
- Evaluation

- This is what we want.
- Metacognitive facets are malleable and can improve either through direct instruction or more organically through experience learning and studying

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Time for meta-metacognition

- Go back to your brain dump and add/delete…

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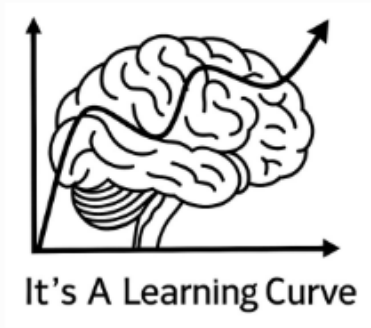




Cogsci In The Classroom

" Ok, fine. But what do you actually **DO**?"

I get asked this a lot, so this page is for '**THIS is what I do***'.

I'll put it in phases, where a 'phase' was **about a year**, with a concrete example where possible. (NB: I was always an extensive user of mini-whiteboards (how to use them coming soon!) – please get a set and use them).

Phase 1 – *Introduced* ***retrieval practice***

Started **weekly retrieval practice** with my classes.
Low stakes – one question from last lesson, one from last week/month, one from a long time ago. 100% correctable.
I'd done quizzes, but adding in 'a long time ago' had a significant positive impact.
Continued **use of mini-whiteboards.**

Example:
Retrieval Practice – Mon 8th Jan
1. Last lesson:
Explain why a charged balloon picks up a piece of paper.
2. Two weeks ago
Calculate the energy stored in a spring with a spring constant of 50N/m if it is stretched by 2mm.
3. Six weeks
Draw a free body diagram for a ball rolling across the ground after it is no longer in contact with your foot.

Phase 2 – *Refined* **retrieval practice**, **more explicit instruction**, less performance

As above… AND changed the RP questions to get **deliberately get more complex/abstract/unfamiliar** over time within each topic.

Example (over time):
Draw a free body diagram for a **ball** falling (ignoring air resistance). Label the forces.
Draw a free body diagram for a **leaf** falling from a tree at a constant velocity. Do not ignore air resistance. Label the forces.
Draw a free body diagram for **you** in a car on a freeway

It took 2 years before I got the courage to …

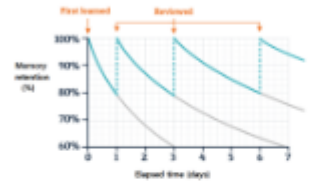
Phase 3 – Teaching metacognition, spaced homework

As above… AND designed a **one lesson introduction to the brain and learning**. Did it with all my classes. (A **bit nervous** doing it).

Started **spaced practice** by deferring **homework** (SLOP) until **2 weeks after we'd done it in class**.

Made most AP (A level) homework is **SLOP** (Shed Loads Of Practice) with interspersed AP questions.

Retrieving things upsets the forgetting curve



Hermann Ebbinghaus, *Memory: A Contribution to Experimental Psychology* (1885)

What will we do this year?

To get things securely in your long-term memory and upset the forgetting curve we will do…

- lots of retrieval practice (lots of questions but NOT about grading)
- lots of SLOP – Shed Loads Of Practice (to make strong connections)
- lots of spaced practice (thinking about things from a while ago)

- You'll use your working memory to process new information
- You'll build up your long-term memory to be better at everything.

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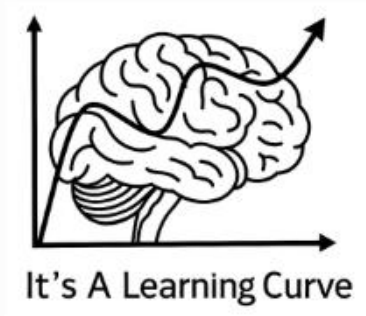


How do we learn*?

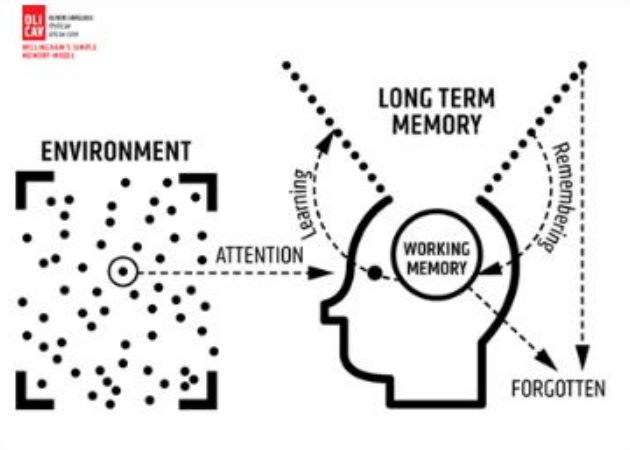
If you like to **watch a video**, watch the video.

If you like to **read**, here's the same information**:

1. Learning is a change to your **long-term memory (LTM)**[1].

- This is key, and this is how learning works for EVERYONE doing EVERYTHING. Physics, basketball, skydiving, playing lead guitar, gaming… tying your shoelaces. Everything.
- Luckily, your LTM is pretty much **infinite**[2].

2. There is a really useful **model of memory**[3] that is widely used:



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And more resources…

Great (short) books… with summaries

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Another great book… with a summary

How Learning Happens 2nd Ed (by Paul A. Kirschner and Carl Hendrick) – Planning Summary

		What	What to know and what to do	… and not do
Memory and cognition		1. Working memory	Working memory (WM) is limited, and more like 4 than 7 can be recalled – don't overload BUT struggle can be good. . Chunking REALLY helps. Use (unlimited) long term memory (LTM).	Don't overload WM AND (the challenge)… Don't make it too simple
		2. Opening the black box	Working memory is dynamic and we have at least 5 WM stores. Cognitive overload negatively affects performance – avoid by chunking/organization.	Don't distract with seductive details (e.g. photos of cats).
		3. Ah yes, I remember it well	Episodic memory (EM) storage (your 21st birthday) can change, semantic memory (SM) storage (e.g. times tables) not so much. Get THEM to link to episodic with semantic for a stronger memory/use dual coding/make meaning to capitalize on EM.	Don't use gimmicks (Swiss rolls in maths) - they will remember the event, not the content.
		4. "What you know, you know"	Everyone has a bunch of schemas (ways info is organised). New information is evaluated against them, schemas adapt. Talk about 'remembering' not 'memories'.	Don't assume they will remember *exactly* - no one does.
		5. Do you know what you know? Metacognition	Metacognition (thinking about thinking) is not fairy dust – you can teach it; you can get better at it. We can model it: planning/ strategy choice, monitoring, evaluation.	Don't teach it as a 'generic' skill – link to domain knowledge.
How does our brain work?		6. A novice is NOT a little expert	Children are NOT small adults. They see the world differently. Things that work for experts DON'T work for novices and vice versa, so don't mix them up. Beware the curse of knowledge.	Don't ask them to do things only experts do.
		7. Take a (cognitive) load off me	You don't learn piano using Rach 2 - break it down. Solving a problem is NOT the same as learning how to solve a problem. Teach steps separately. Heed human cognitive architecture.	Don't teach a complex system using complex systems.
		8. Dancing in the dark	Skilled = turning declarative into procedural knowledge Novices use weak strategies (e.g. trial and error/means-ends), need help to move to expert problem solving (backwards from solution).	Don't engage in applications/problem-solving too soon.
		9. An evolutionary view of learning	We easily learn things we need for survival (bio primary) BUT reading, writing, science… (bio secondary) need effort (tell them!) Help Ss manage interests, use bio primary to motivate (carefully).	Don't use too many gimmicks/novelties to appeal to bio primary.
		10. One picture and a thousand words	There are two cooperating memory systems: verbal/non-verbal. Most efficient to use both so e.g. integrate text into diagrams or talk around your diagrams. Use LOTS of examples for abstract concepts.	Don't use unnecessary images/read PowerPoint slides.
Prerequisites for learning		11. What you know determines what you learn	Prior knowledge is key - be clear about what is needed, reteach it if necessary, give them a framework to work from Go from general concepts to specific – do comparisons old to new.	Don't assume they know it, don't use what *you* know as the start point.
		12. Independent learners	Independent learning is NOT a good way for a novice to become an independent learner. Make sure they have requisite domain knowledge. Modelling/talking helps them learn self-regulation.	Don't say 'do your best', don't set novices independent tasks.
		13. Beliefs about intelligence can affect intelligence	'Entity' theory of intelligence = fixed, related to performance goals. 'Incremental' theory = changeable, learning/ mastery goals – set up mastery through challenges, talk about effort producing gains.	Don't use 'smart' to refer to Ss, don't go on about grades.
		14. … thinking makes it so	Self-efficacy (belief in one's ability to do a task) is key – is boosted by early success, so give them that; success begets motivation. Teacher modelling helps alleviate anxiety. Talk about that.	Don't use nebulous language or encourage mutual competition.
		15. Perception of achievement is the key	What you attribute your achievement to is more important than achievement. Your perceived locus, stability, controllability is as significant as actual. Point out things THEY control.	Don't attribute success to things outside their control/praise too much.
		16. Where are we going and how do we get there?	Students can be mastery oriented or performance oriented, both can work, and happen at the same time. Fear of failure inhibits both Show Ss that mistakes are OK.	Don't use performance to assess mastery (or tell them they're the same).
Which learning		17. Why scaffolding is not as easy as it looks…	… because it's about how the problem appears to them, not you. Help them see the difference by talking out loud. Help them build low level skills + increase difficulty, reduce scaffolding.	Don't think they see it like you see it.
		18. The holy grail	1:1 tutoring is 2-sigma better than classes for average students. Can't tutor but can: use advance/knowledge organizers (KOs) at the start, summaries at the end. With mastery learning all can achieve.	Don't use 'hands-up'. Don't give out KOs at the end.
		19. Problem solving	Students' internal conceptualizations of a problem (problem space) is different to ours. Teach how to selectively search problem space, break it down, know where to start. Practice (with variety) is GOOD.	Don't call it 'Drill and Kill'. Don't keep *your* mental models secret.
The teacher		20. Activities that give birth to learning…	… are mathemagenic, will 'make the horse drink'. Learning involves object orientation, selection, translation, processing INSIDE the learner – we have to get conditions right so they DO something inside	Don't assume they will 'drink' because you led them there.
		21. Zoom out to zoom in	Elaboration theory say students need contextual understanding of the domain. Start lesson sequence with 'epitome' of topic/task Sequence: simple-complex, general-detailed, concrete-abstract.	Don't give discrete chunks without big picture, or vice versa.
		22. Why discovery learning is a bad way to discover things	Human cognitive architecture has possibilities AND limitations; LTM is (virtually) infinite, 'discovery' can overload WM. Learning is a change to LTM. Use explicit instruction that takes architecture into account.	Don't use minimally guided instruction with novices.
		23. Direct instruction (Rosenshine, who says…)	…begin with review/new stuff in small (limited) steps/detailed instruction/lots of Qs + check for understanding/ SLOP/think aloud, model steps + worked out solutions/ask them to explain/provide feedback + corrections/move to independent practice.	Don't assume 'learner-centred' is better. Don't conflate DI with lecturing.
		24. Assessment *for* not *of* learning	Research says assessment of progress must inform you and student on what to do next. Formative assessment = 'responsive teaching'. Give back some work with comments only/use rubrics, peers.	Don't just do summative assessment. Don't always grade.
		25. Feed up, feedback, feedforward	Getting them to act on feedback is key. Feedback continuum: corrective (right/wrong)/directive (how to do it; reteach)/epistemic (think about how to do it better); Ss should work harder than you.	Don't say the equivalent of 'be funnier'/praise the student not the work.
		26. Learning techniques that really work	Students don't know how to study well, they forget (Ebbinghaus). High impact: practice testing/distributed practice Med impact: elaborative interrogation/self-explanation/ interleaved practice	Don't assume they know *how* to learn. Don't assume you do!
Learning in context		27. Why context is everything	Students learn from observing others, learning is not context-free. Prior knowledge is a bigger factor to learning than age. Carefully sequenced explicit modelling better than getting them to work it out. Novices need modelling that is *complete*.	Don't ignore social learning (role play, peer teaching). Don't use age as a gauge.
		28. The culture of learning	Cognitive apprenticeship is useful structure – teacher as role model. Contextualise tasks to help integrate knowledge/skills. Practice part-tasks *first*. Discussion can produce shared language of learning.	Don't think you can teach generic skills.
		29. Making things visible	4 dimensions of apprenticeship: content, method, sequence, sociology. Explicitly describe how you navigate the problem space – think aloud. Put tasks in authentic contexts/multiple situations.	Don't assume they know what you are thinking.
		30. It takes a community to save $100 million	Teachers need communities of practice = people coming together. Build one to share domain knowledge, and community (belonging means engagement, imagination, and alignment).	Don't have hard or protected boundaries around your community.
Cautionary tales	VAK	31. Did you hear the one about the kinaesthetic learner… ?	Digital natives and learning styles do NOT exist. Teach how to find reliable and valid information online, and how to navigate the problem space.	Don't ask them how they learn best – they don't know.
		32. Activities that give kill learning…	…are mathemathantic. What works for some can be counter-productive for others (expertise reversal effect) – beginners need much guidance, more experienced learners don't… first do no harm.	Don't assume everything works for everyone – check first.
		33. The medium is NOT the message	It's not the medium but the instructional method that influences achievement. Select the most appropriate medium – less is more Just because they are engaged doesn't mean they are learning.	Don't fall prey to the hypes around (multi)media.
		34. The ten deadly sins	1. The learning pyramid is not correct 2. Learning styles are not correct 3. Young people are not digital natives 4. Children/people can't multitask 5. You can't just Google it	6. You don't learn to solve problems by solving problems 7. Discovery learning is not the best way to learn 8. Motivation does not lead to learning 9. Grit isn't different from perseverance 10. Schools don't kill creativity
Lethal mutations		35. Lethal mutations – AVOID ALL of these:	1. Rosenshine → checklist of must-dos 2. Desirable difficulties → making them fail 3. Retrieval practice → every lesson 4. Constructivism as philosophy → use as pedagogy 5. Biologically primary → instruction isn't needed 6. Dual coding → illustrations for their own sake	7. Interleaving → rotating subjects 8. Cognitive load → striving to minimize load 9. Zone of proximal development → group work 10. Self determination theory → give autonomy 11. Success begets motivation not vice versa 12. Kolb Experiential Learning Theory → learning styles 13. Flipping classrooms → 3 wrongs do/don't make a right.

Made by Helen Reynolds, @helenrey Graphics courtesy of https://thenounproject.com/

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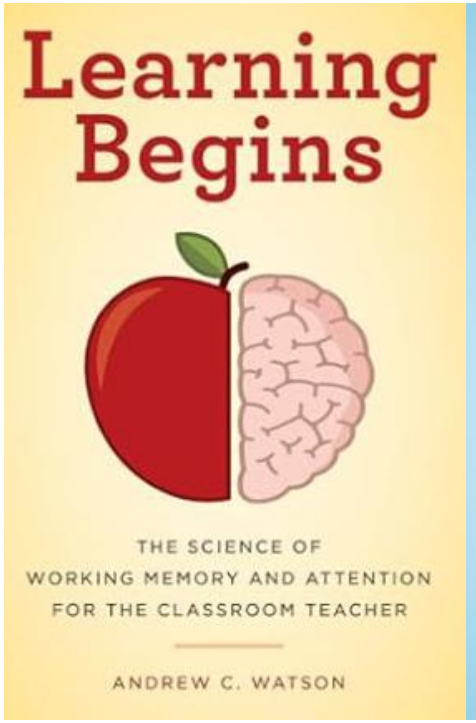
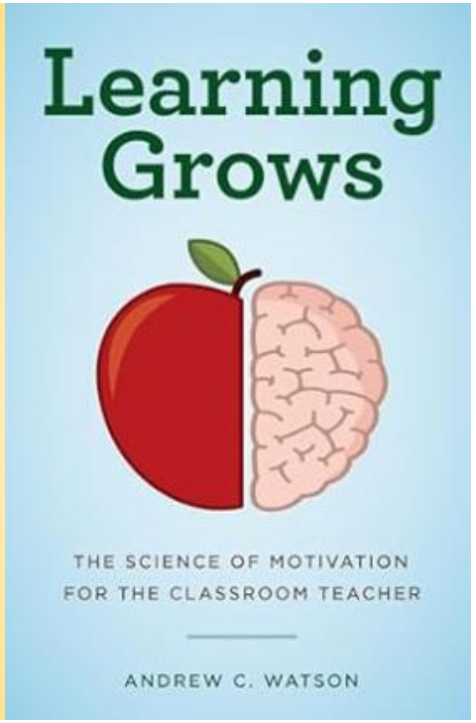
Two more great books (with summaries):

Planning Summary – Learning Begins/Grows by Andrew Watson **by Helen Reynolds (@helenrey)**

Learning Begins (The Science of Working Memory (WM) and attention)	Do This/Remember This
PART I WM: 1.Memory at Work: Table analogy – selecting photos for an album: STM = small table, LTM = box of photos, processing = shuffling/sorting photos. Declarative = knowing that, procedural = knowing how. STM now called WM a. Uses - where we hold info to rearrange/ combine/ essential for academic learning b. Limitations – capacity, duration c. Development – increases (a bit) with age, cannot deliberately increase capacity with artificial practice (analogy – volleyball players on stilts)	
2.Two Burning Questions: 1. How can we anticipate it? WM overload = like too many photos on the table, maximum overload with too much unrelated material that needs to be manipulated/ combined in a creative way: Dark Force analogy – by being creative/ expansive we can CAUSE the overload e.g. when giving many instructions, giving them choice, getting them to use technology, so projects need planning so they have expertise/vocab/connections/patterns 2. What does WM overload look like when it happens? Can fail at holding and/or at processing, how they can't do things tells you which, + their behaviour – atypical distractibility, catastrophic failure (unable to do normally simple things) – it will bounce back	
3.Solving Working Memory Problems: #0 – Adopt a WM Perspective – notice WM demands #1 Solve WM problems with LTM – connecting new info to LTM info dramatically reduces WM demand, deliberately chunk new info, establish routines. #2 Redistribute WM demands – choose what to tell them first (the majority), save exceptions for later, use both visual and verbal channels, they can take in twice as much, remember listening+processing+deciding+writing =WM overload #3 Reduce WM demands -choose #examples/types/work that maximize learning without risking WM overload #4 Normalize struggle – tell the smart people do NOT learn without struggle, get them to talk to each other about struggle #5 Reduce pressure – pressure (grades, group working/depending on others, supervision) can convert a high-WM-capacity student to a low-WM capacity-student	
4. Working Memory Review with FAQ 1. Multitasking – increases demand, 2. ?+/-2 in WM – not a hard and fast rule, 3. increasing WM – no proven methods currently, 4. students with WM deficits – benefit from solutions in part 3, 5. New to teaching – be systematic in trying solutions above, protect your own WM from overload, 6. kinesthetic channel – there isn't one	
PART II ATTENTION: 5. Redefining Attention 1. What is attention? – not a single thing = alertness (how awake), orienting (what stimuli are they attending to), executive function (what are they putting effort into) = AOE 2. What can we do? – watch for examples of attention issues in the classroom and categorise using AOE, see when 'pay attention!' might work, look for examples with our own attention	
6. Alertness There's a threshold - high or low alertness precludes learning 1. Mind the Leopard – we are alert to visual novelty evolutionarily, 2. 10 minutes, and Beyond… – no support for fixed lengths of attention by age, changing activity can halve inattention, 3. Justice is Blind and Tired – human brains can't be alert for hours on end, 4. Movin' On (Waking Up) – physical movement (or watching you move) can increase alertness	
7. Orienting - A: reduce internal distraction, 1. We're having a Heat Wave – temperature matters, affects orientation, 2. Euphemism, Please – adolescents are sensitive to bathroom needs 3. Don't Be Hangry – hungry students don't learn 4. Hormones – choose **B: reduce external distraction** 1. Beyond Noise Pollution – noise/smells/posters etc. can distract 2. This Does Not Compute – distinguish exotic tech = tech that has no place from domestic tech = useful tech (laptops, sensors etc) **C: increase salience of material** 1. Reality Check – students don't think about salience in the same way 2. This is only a quiz – quizzes cut mind-wandering 3. "Tribal Classrooms" – classes can have their own identity/esprit de corps	
8. Executive attention (EA) What does an EA mistake look like? 1. Chocolate cake – prudent vs impulsive students – impulsive + high WM demand = answers that make no sense 2. Measuring a reservoir – EA requires willpower, all acts of willpower drain the same reservoir, 3. Tick Tock – time pressure impacts performance on high WM demand tasks 4 Motivating Environments – feeling of relatedness, autonomy and choice enhance EA, improve situation model (picture in your head)	
9. Attention Review with FAQ 1. Class period – key variable is teacher, start earlier if possible (biology) 2. ADD/ADHD – find ways to stimulate that don't distract others 3. Distinct or combined – can have more than one AOE problem 4. Is it always bad? – inattention affects learning 5. Training? – A and O probably not, E possibly (Tools of the Mind – Diamond) 6. Emotion – WM + emotion + LTM + motivation always interacting	

Learning Grows (The Science of Motivation)	Do This/Remember This
We already know a lot about motivation, Mind, Brain, Education (MBE) advice should have research and be surprising. MBE Principles: 1st – Don't just DO this thing, THINK this way, 2nd – Don't obey or imitate, translate, 3rd – Averages matter, but no individual is average. **PART I MINDSET: 1.Starting at the Fourth Step (what we see):** In the face of struggle some students charge (excited, stimulated, undaunted), some students retreat (gloomy, go backwards, give up) 1. The Motivation Paradox – why do strategies designed to motivate not work? What makes some students retreat? Is not related to capability, but to the Third Step: their explanation – If struggle = insufficient ability -> retreat, if struggle = insufficient effort -> charge, 2. Classroom Strategy 1 using praise of effort not ability shifts students' perceptions of their enjoyment, makes them more strategic, less likely to lie about their grade. 3. Classroom Strategy 2 focusing down using praise of precise strategy not person because praise for effort alone can look like a consolation 4. Classroom Strategy 3 decouple praise from self-esteem – don't give person praise to students with low self-esteem, comforting feedback can make students focus on ability, 5. Classroom Strategy 4 Adding 'yet' changes hints at a more successful future	
2.Second Step: Rehearsing, Not Performing: 1. Why do students come to school? Some have performance goals PG (show off how much they know), some have learning goals LG (learn more than they already know) 2. How does that affect their response to struggle? PG students say effort is bad/failure/means you are not smart/fear mistakes/focus on test scores, LG students see effort as good, mistakes as necessary, people can have PG/LG in different situations	
3.The First Step (at Last): 1. Mindsets – fixed = intelligence is innate and cannot change, growth = intelligence can increase over time, mindsets predict response to struggle, GM means more learning/more processing of wrong answers, FM get hung up on wrong answers 2. Strategy 1 - Messaging - explicit messages do affect mindset, also indirect messaging through mentoring, and what we teach them about the brain and learning 3. Strategy 2 - Grading – if students can correct work they talk more about learning and less about test scores 4. Strategy 3 – Disciplines change -growth disciplinary mindset (no research), schools subjects in expanding fields.	
4. The Mindset Controversy with FAQ 1. GM doesn't mean people are equally smart – there are some limits 2. Is FM/GM subject specific? – there are distinct mindsets around broad categories (academics/social/sport), 3. What about grit? – grit = charge, 4. Is it FM to say WM is limited? – GM says learn to use it better, 5. What about success? – GM sees success as confirmation effort has worked, FM that they are smart, failure is diagnostic – shows limitation (FM) or limitlessness (GM) of intelligence 6. Are there age limits? – no 7. Are mindsets culturally specific? – no research	
PART II STEREOTYPE THREAT: 5. (De)Motivation and Stereotypes 1. What is the problem? – perception that others judge you based on stereotypes = stereotype threat ST in race, gender, sexuality, age, socioeconomic status, can affect: cognitive performance and more, can both impede/enhance performance, culturally specific (different stereotypes), ST is a response to conditions (like mindset), teachers can change the conditions 2. Mapping ST paradoxes – four preconditions that lead to ST: #1 Salience (relates to student e.g. ST about swimming affects the swim team), #2 Second-hand belief (believing the teacher believes the stereotype affects the student even if the student doesn't believe it) #3 Skill and interest (being good/interested makes you more vulnerable to ST because you care, does NOT protect you) #4 Heavy lifting (ST makes easy work easier and difficult work more difficult) 3. Effects of ST internal and external hypervigilance + stress = distracts/clutters WM	
6. Changing the Motivational Climate Strategy 1 Addition by Subtraction – reduce salience by not having it there/not displaying it/producing that environment Strategy 2 stereotypes applies FM to groups to extremes, GM largely makes ST irrelevant (brains change, normalize struggle) Strategy 3 avoid 'solos' – being the 'only one' can increase salience	
7. Assessment and Stereotype Threat FAQ 1. Is there a ST controversy? – yes, but research suggest there are strategies that work, 2. Do stereotypes ever benefit people? Yes, but don't use it – can backfire . 3. What about students with LD? No research as yet 4. What should these strategies look like in my classroom? You can/should work that out! No one can tell you what will work. Try it! 5. Would students benefit from know about ST? Tricky language – frame as 'negative stereotypes that are widely known but have nothing to do with how well you will do on this test/in this subject'.	





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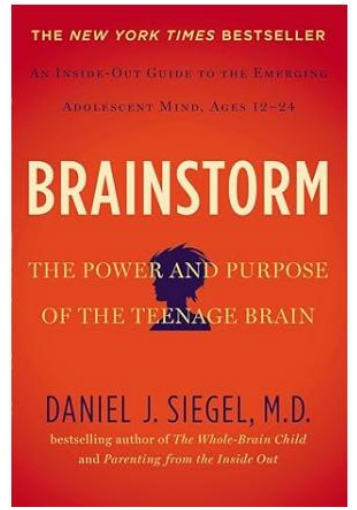
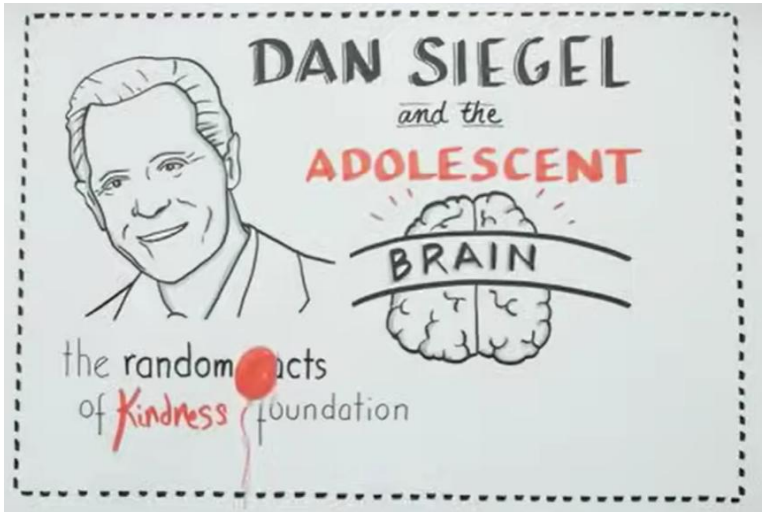
A metacognition P.S.… dopamine



- Buckets!

Adolescent brain

Adult brain



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The ‘takeaways’….

- Reframe ‘thinking about thinking’ as ‘learning about learning’
- Metacognition = knowledge + regulation
- You can teach it explicitly, like anything else

- PS. Don’t forget the dopamine!

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Feel free to contact me!

- Website: itsalearningcurve.education
  - This presentation and handout
  - Strategies for using cogsci in the classroom
  - Cogsci reading list
  - All my book summaries!

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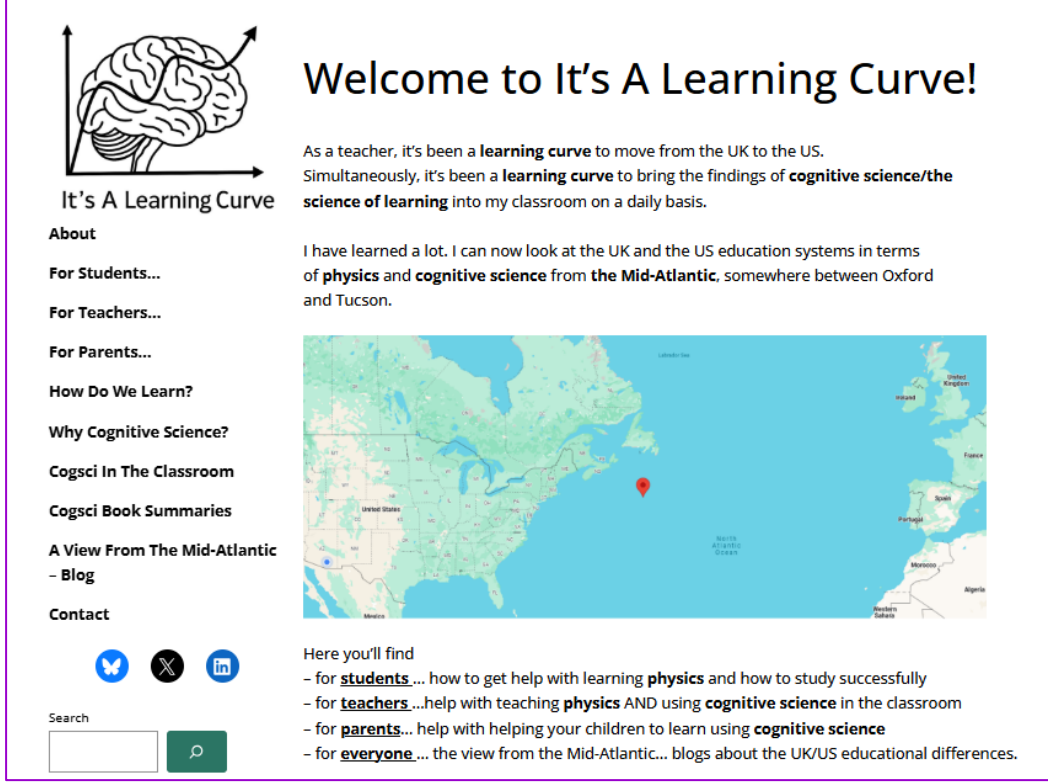

... and thank you very much for listening!

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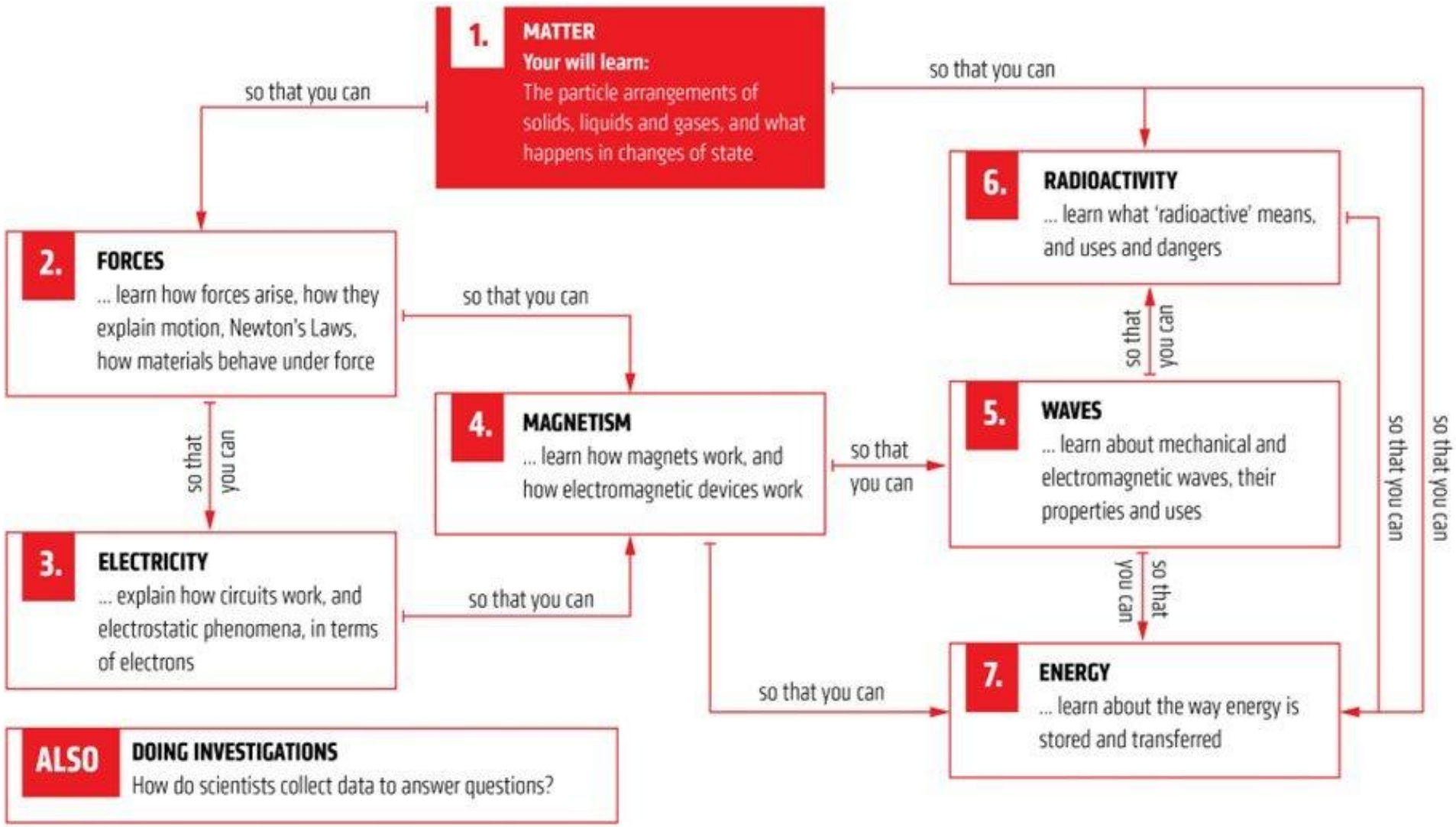
MAP OF PHYSICS

Why are we learning this?

Physics is concerned with explaining and predicting the phenomena that we see or can detect, or make happen.
The areas of study are interconnected as shown below.



ALSO **DOING INVESTIGATIONS**
How do scientists collect data to answer questions?

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