

# Evidence-based Learning Strategies

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# Intuitions are NOT always Right



Our intuitions as to *how we learn* and *how we should teach* are *not* always correct.



Our intuitions can lead us to pick the wrong learning strategies.

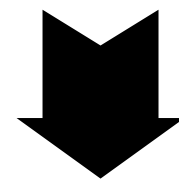


Once we land on a learning strategy, we tend to seek out evidence that favours the strategy.

Years of experience as student



Trusting your intuitions more about learning



Confirmation Bias



Eg. How to study for an exam?

**Read & reread the day before**

- Easier
- Learner feels more confident.
- Poor long term retention

**Spaced interleaved reading & testing**

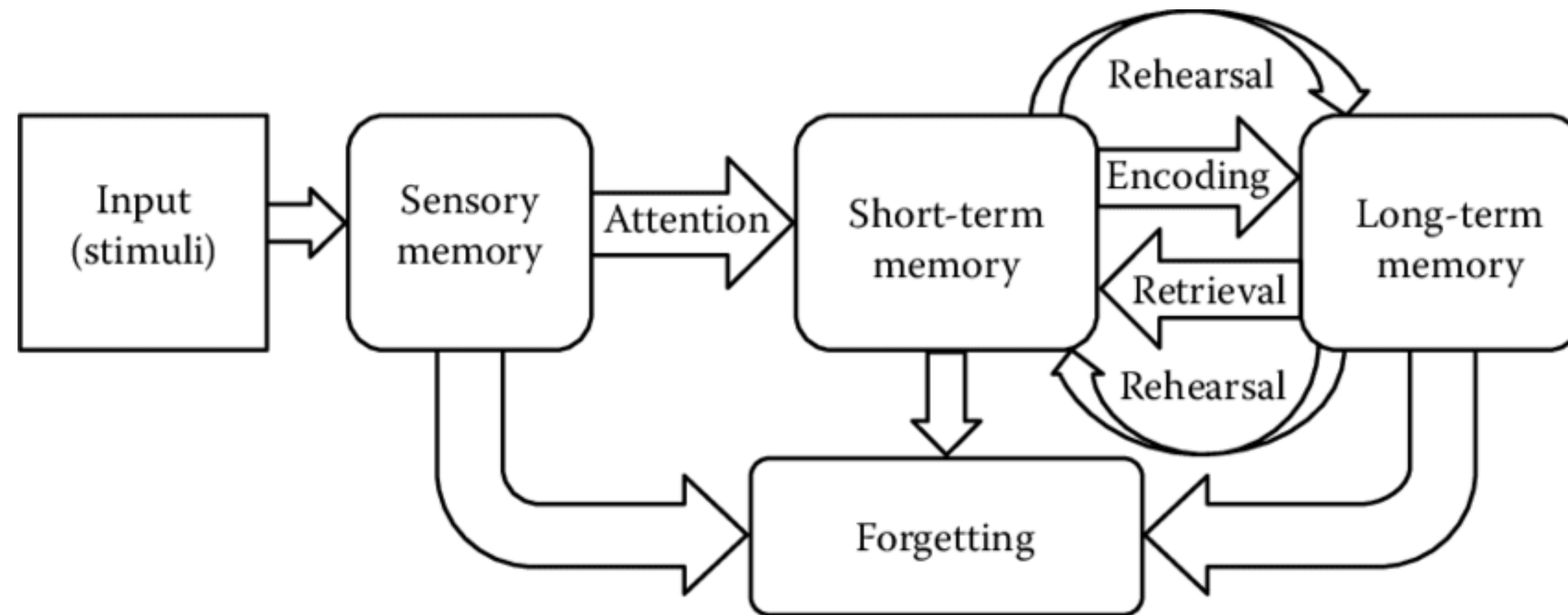
- Difficult
- Learner feels less confident.
- Best for long term retention

# Outline

1. The Cognitive Functions Perception, Attention & Memory
2. Their Implications for the Classroom
3. Effective Learning Strategies
4. Small Teaching Methodology



# Information Processing in the Brain



**Atkinson-Shiffrin model of memory (1968)**

The cognitive functions **Perception, Attention & Retrieval** are central to Learning as an activity.

Their specificities determine whether a particular learning strategy is effective or not.

# Perception

*What one perceives differs from person to person, and from situation to situation.*



- Sensation is objective, whereas perception is subjective.
- Perception allows us to make sense of the world.
- Top-down processing involves applying prior knowledge to understanding a situation.
- Humans tend to mostly engage in a lot of top-down processing.



- Students bring different types and levels of knowledge to the classroom.
- As teachers, we need to be sensitive to different levels of understanding.
- Sometimes we as teachers can lack awareness of how students process information.

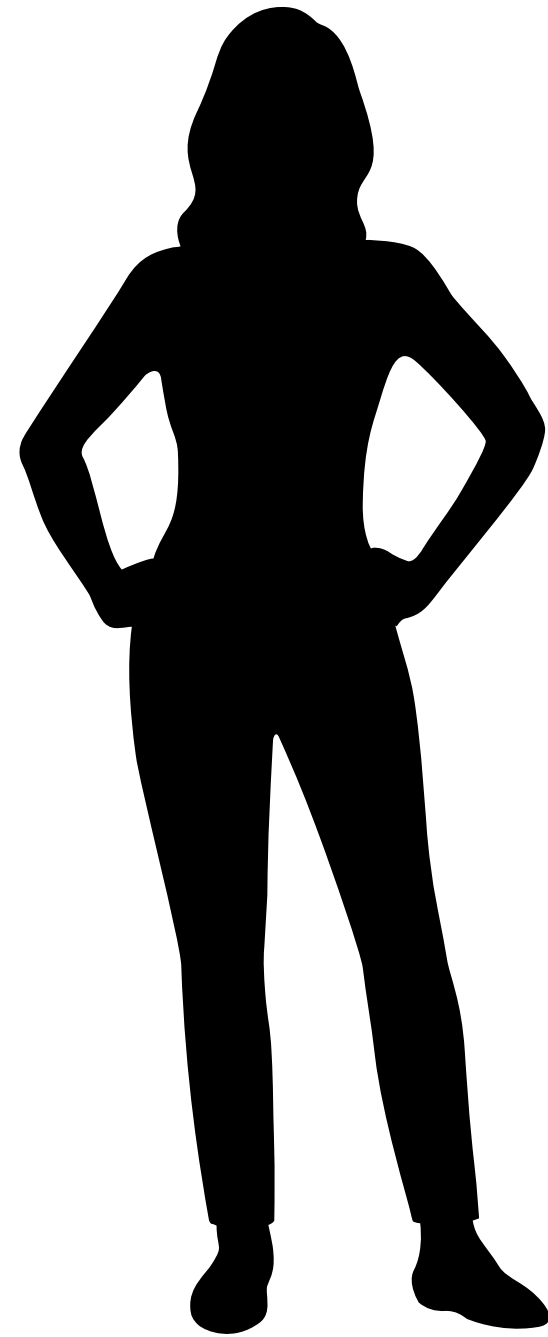
## The curse of knowledge



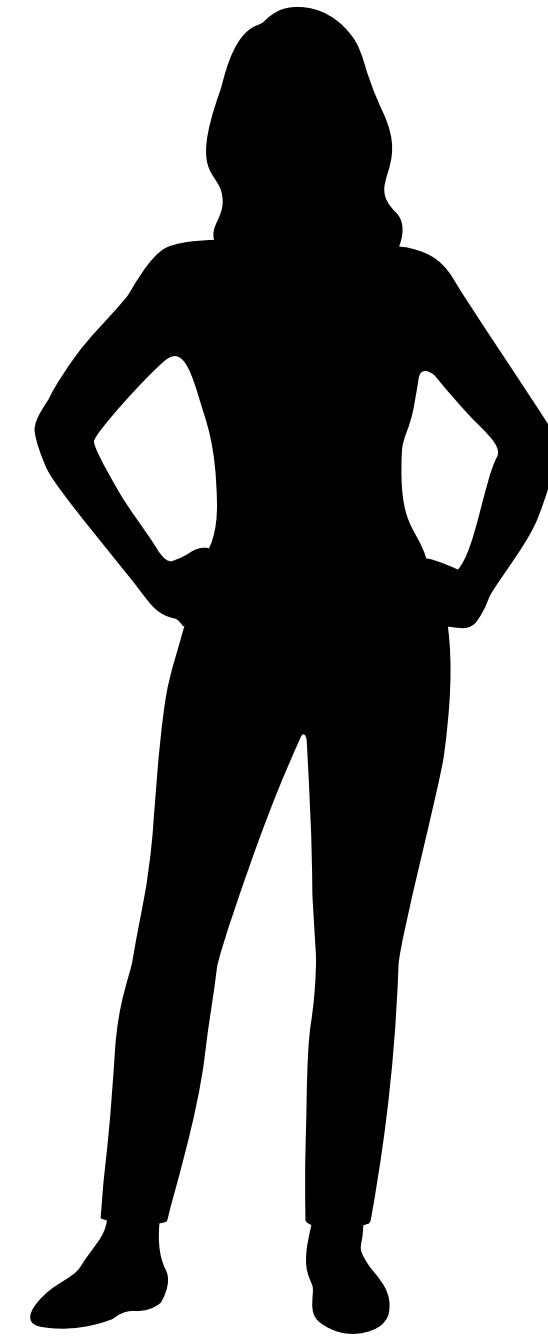
*Phenomenon of thinking something is easy or obvious because you have had a lot of experience with it.*

**Tip:** *You can deliberately mitigate your own overconfidence by thinking about possible alternative answers or explanations, or paraphrasing the material.*

*“Intelligently leaves small portions for the students to fill in the details”*



**Who is  
more  
effective?**



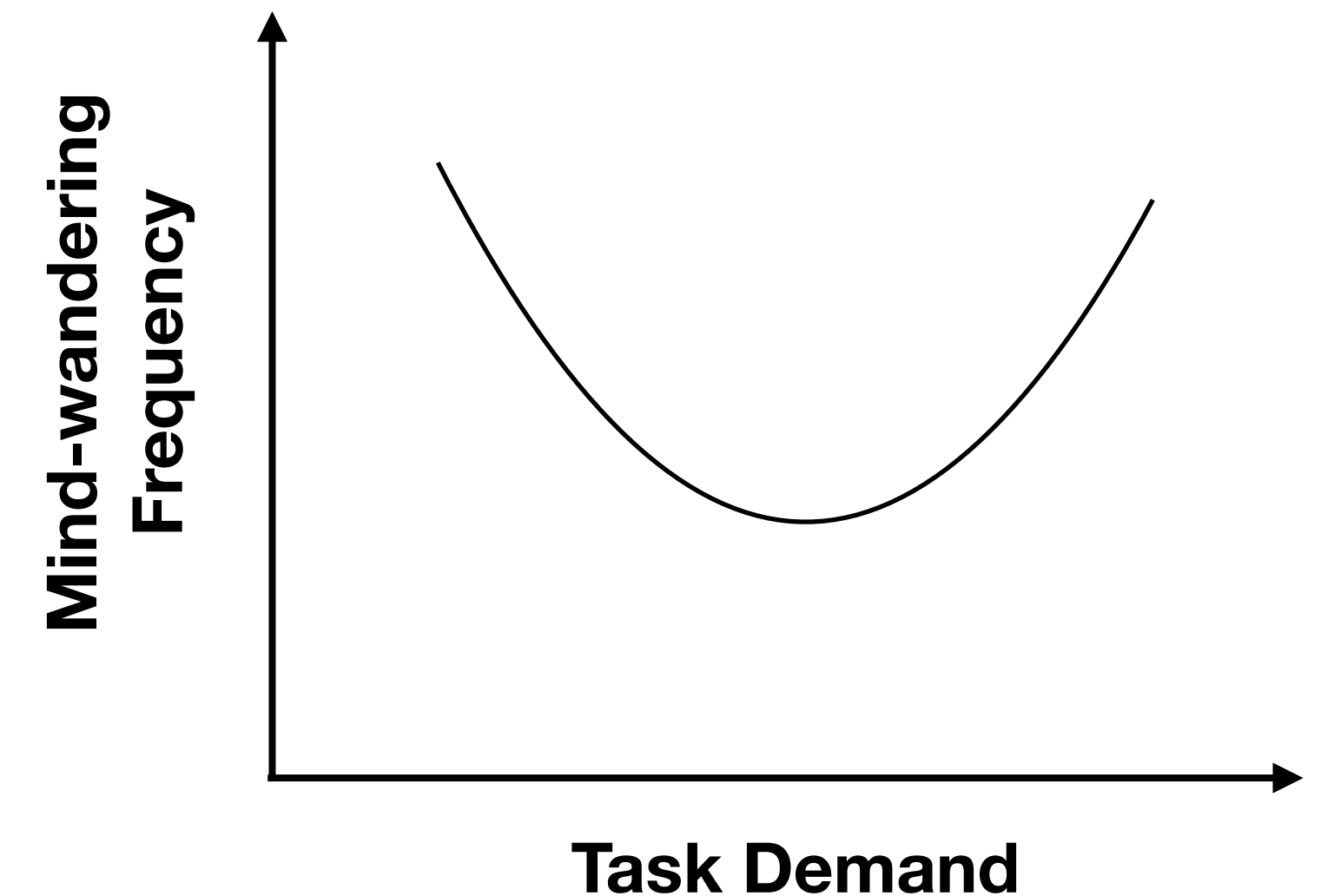
*“Explicit about most details”*

# Attention



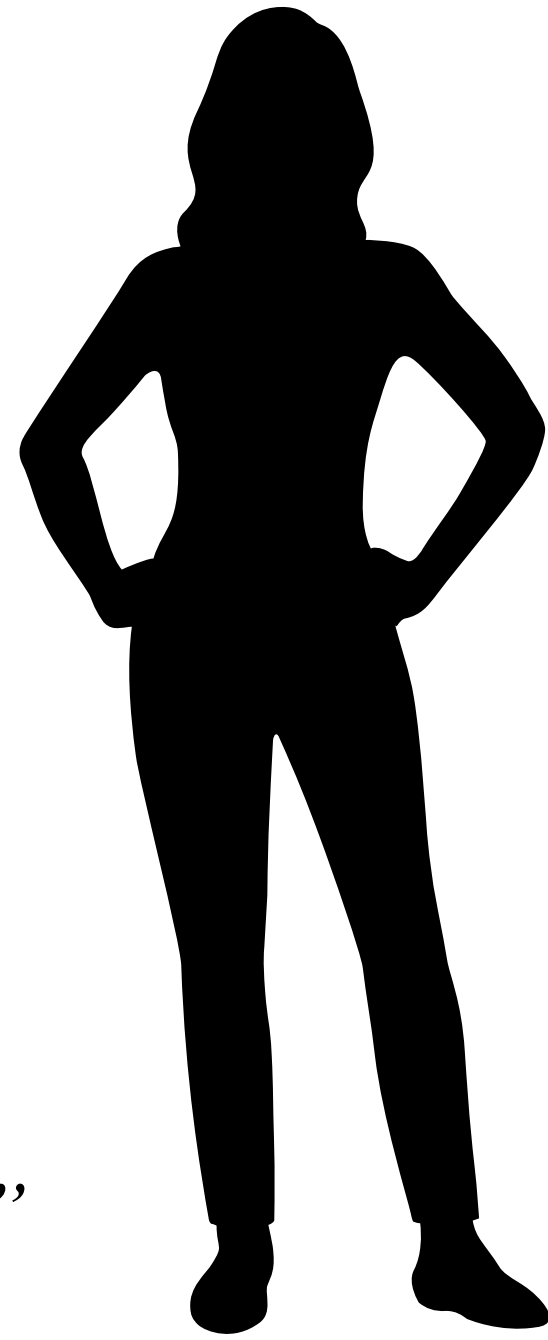
- An important feature of attention is the ability to selectively focus on just one stimulus at a time.
- Switching between two tasks decreases efficiency and slows down reaction speeds in both tasks.
- Attention is a “**limited-capacity resource**”. It must be directed towards the most important information.

- The likelihood that a student will pay attention is determined in part by the **saliency** of the material.
- Both individual and situational interest affect the extent to which we pay attention in a learning situation
- **Mind-wandering** involves getting distracted from a task by your own thoughts.

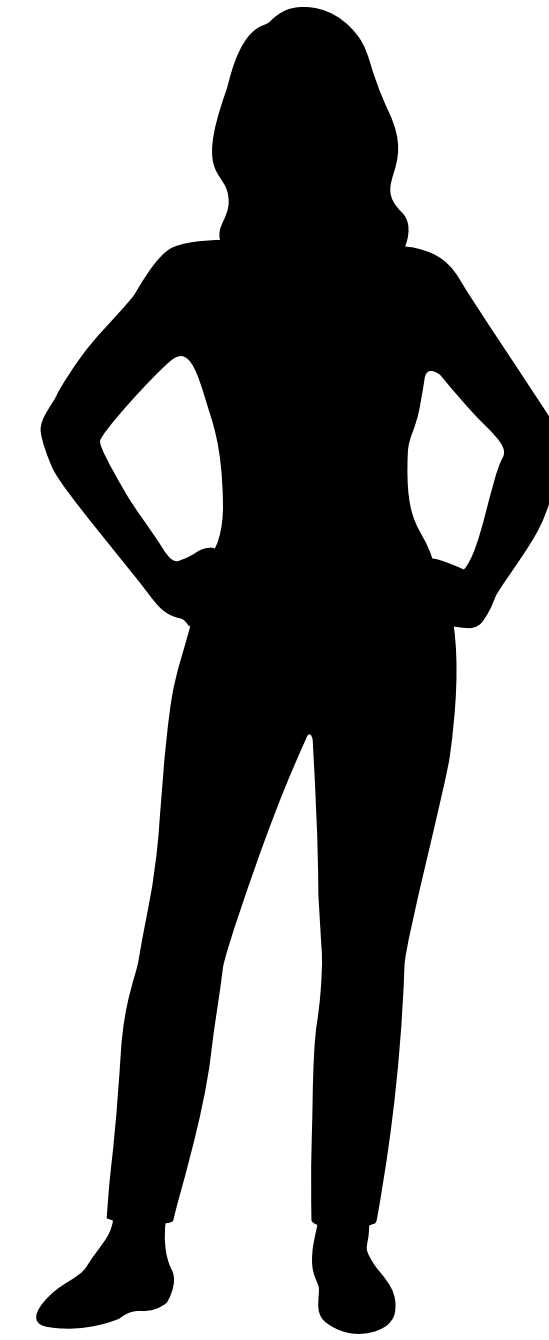


- As a rule of thumb, about **half the time**, students are not paying attention to what the teacher is saying in class.
- Mind-wandering can be problematic because it can result in students missing important information.

*“I maintain my pace; don’t worry, they will catch up. They need to learn to do so.”*

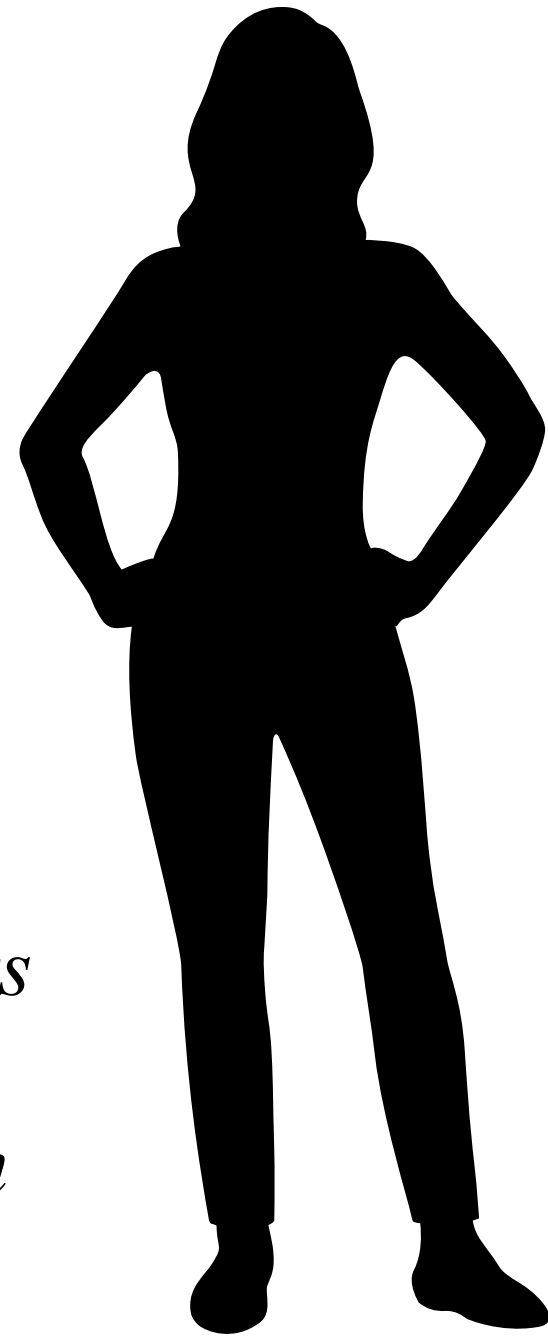


**Who is  
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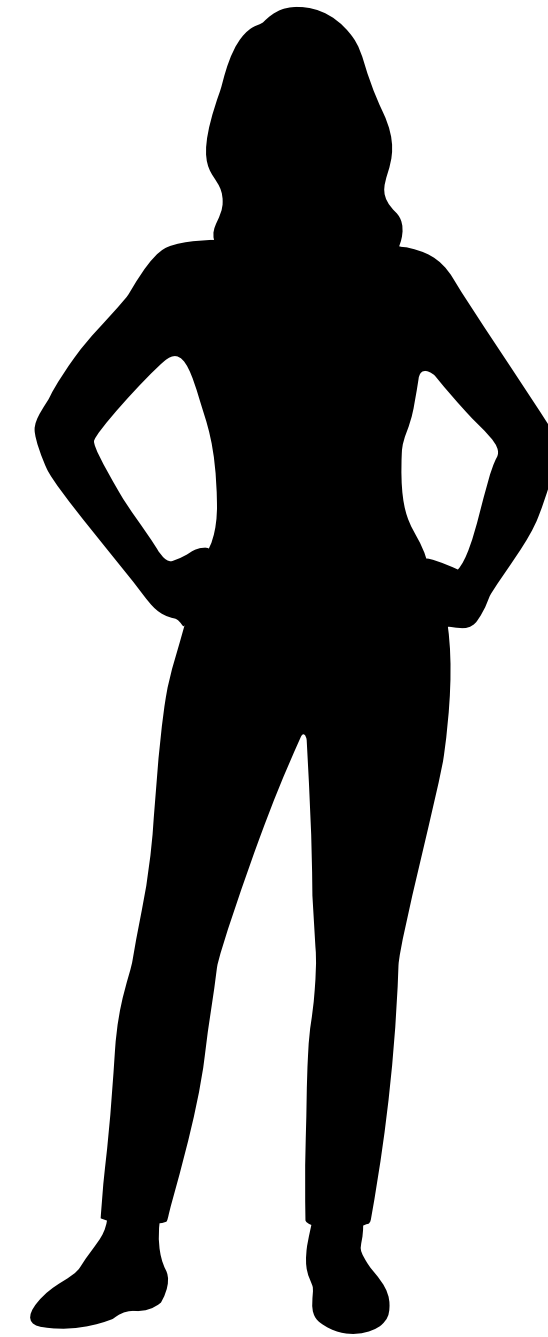


*“I adjust my pace if I find them struggling”*

*“I fully utilise the class hours for the lecturing, students should do the rehearsals on their own after the class”*



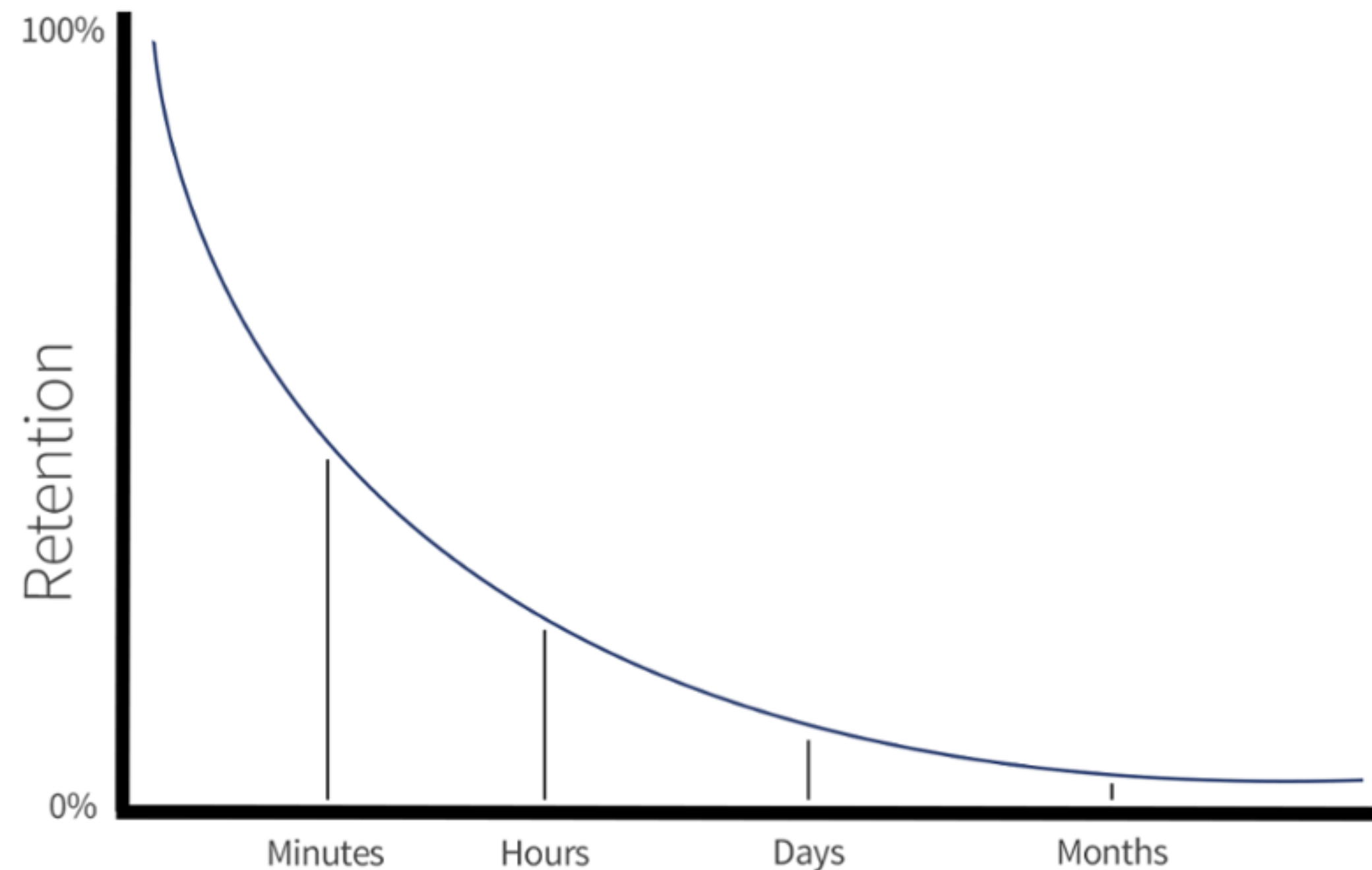
**Who is  
more  
effective?**



*“I take breaks during the lectures.”*

# Memory

- Everything you do requires memory in some form or another.
- “Memory is not like a library (or a computer); memory is **reconstructive**.”
- We don’t lay down objective, definitive memory traces that are later retrieved verbatim.
- Every time you retrieve a memory, you **reconstruct** it, activate it, and may alter it.



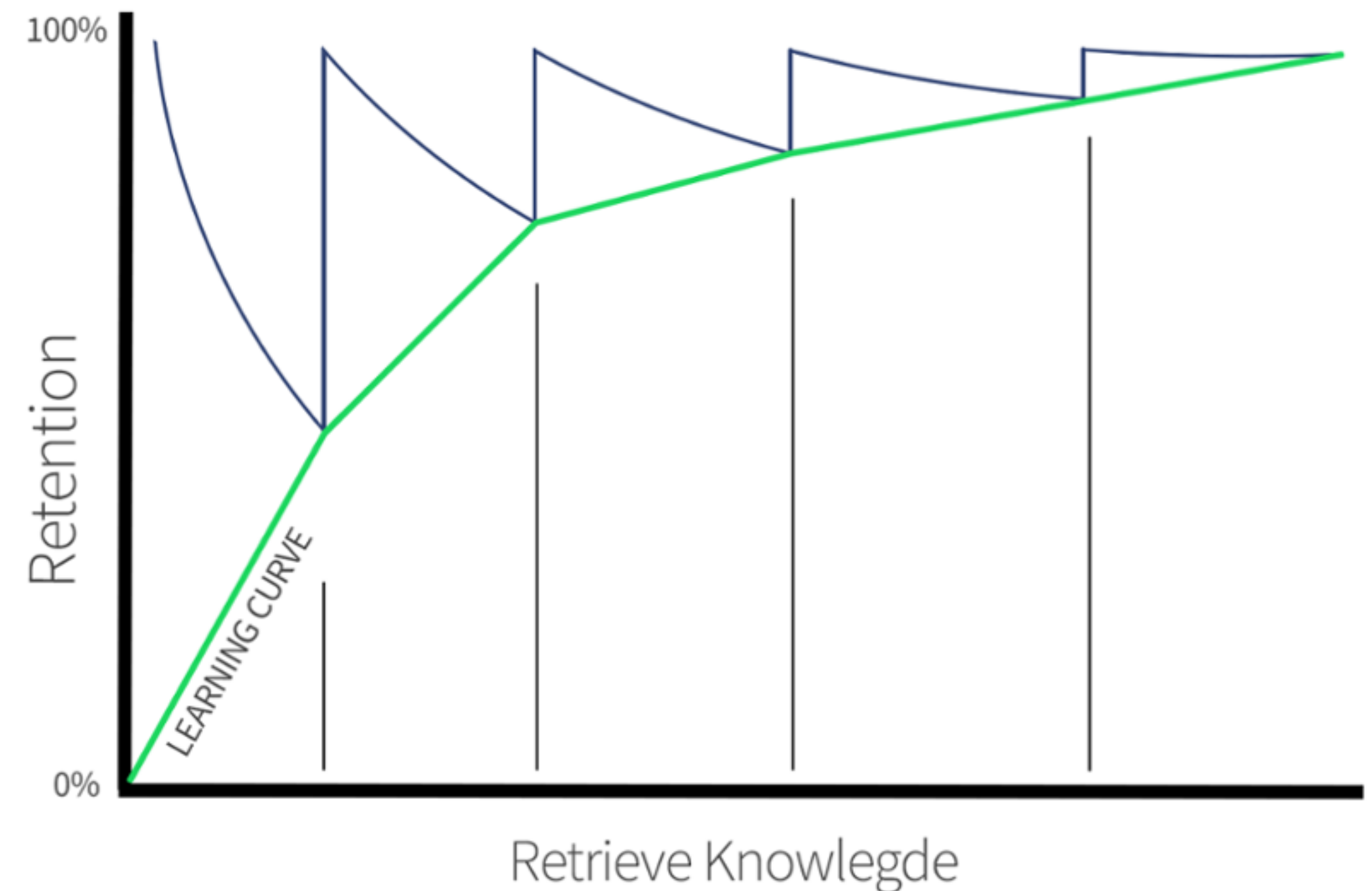
**The Forgetting Curve**  
(Hermann Ebbinghaus 1885)

- The fact that memory is reconstructive necessarily means that memory is not objective.
- Details from your imagination can become part of your memories.
- As soon as you encode something, you immediately start to **forget** it.

# Getting things to Long-term Memory

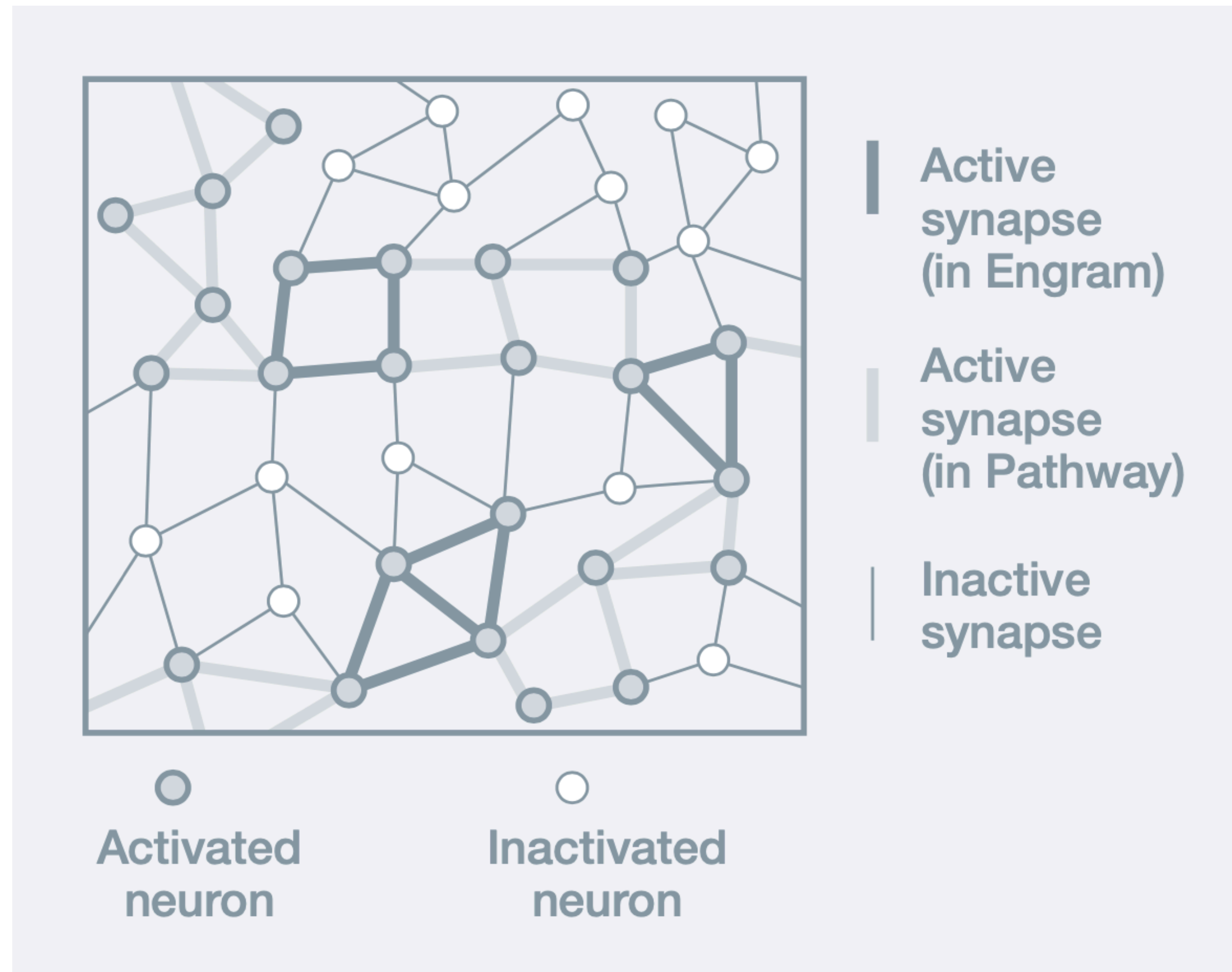
## 4 stage model of Long-term Memory

1. **Encoding** - If a memory is never encoded, then it was never created in the first place.
2. **Consolidation** - Just because a memory is encoded, it does not mean that it will be recallable later; it needs to be consolidated.
3. **Storage** - Following consolidation, memories are officially “long-term memories”.
4. **Retrieval** - When the memory is retrieved, it is reconstructed, reactivated, and re-consolidated.



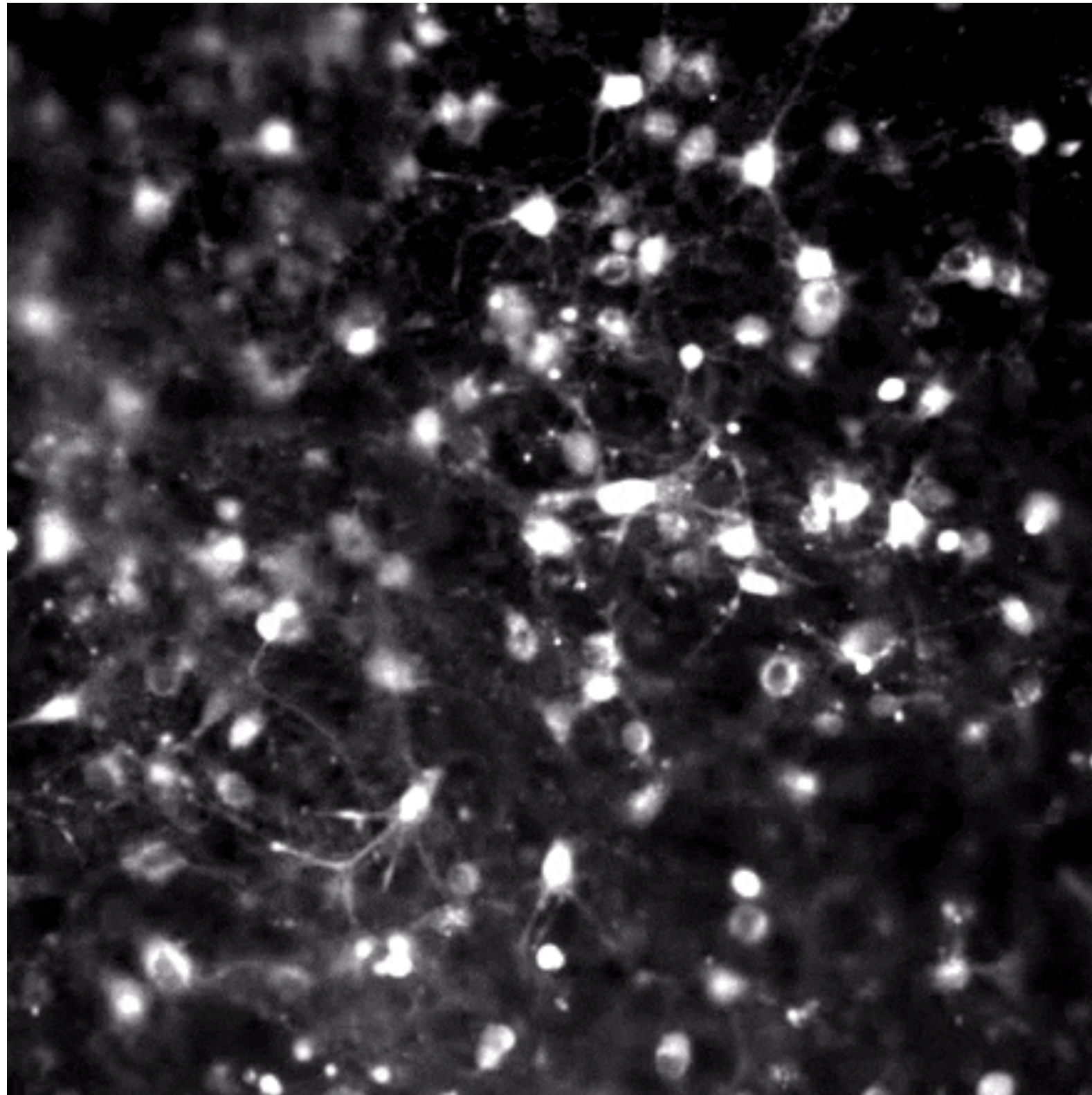
**The Learning Curve**

# Memories in the Brain



- The brain is made of neurons, that communicate with each other.
- An active neuron may activate another neuron if they have a mutual connection (synapse) that is strong enough.
- When active neurons in a certain group are synchronously active, we are able to recall a concept or an episode, or to execute a procedure.
- This pattern of active neurons an “*engram*”.
- Engrams can be connected to one another to create associations.
- One specific memory can be composed of multiple engrams, that are connected to each other by neuronal **pathways**.

# What happens when we learn?

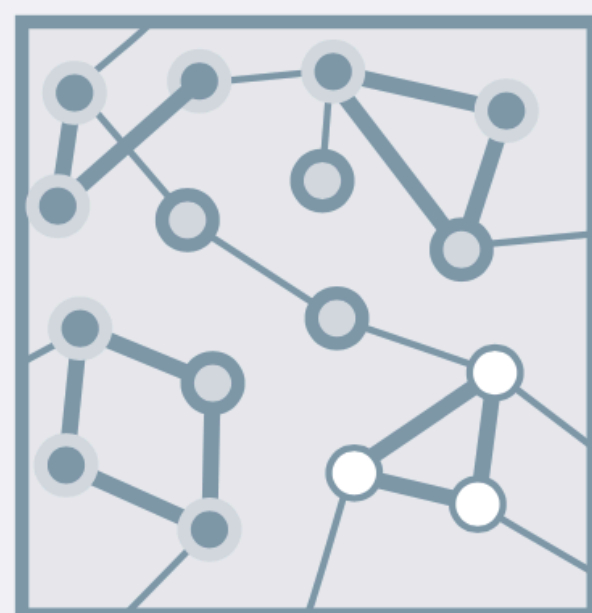


- When we learn something new, specific groups of neurons are firing in our brain as a response to the incoming information, creating patterns.
- Some of these patterns are absolutely new; others represent things that we already know.
- The crucial question is: will these first-time-ever-active patterns be reproducible in the future?
- In order to remember, we need to reactivate a highly similar pattern to the one that was active during learning, but without the original stimulus.

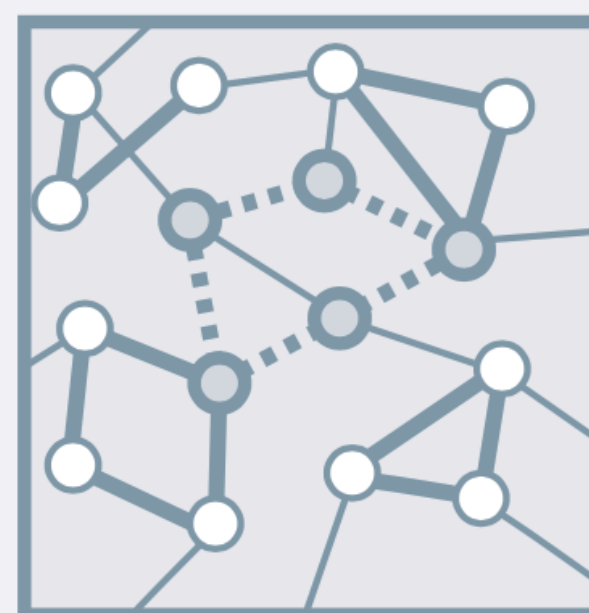
# Consolidation & Retrieval

*Neurons that “fire together wire together”*

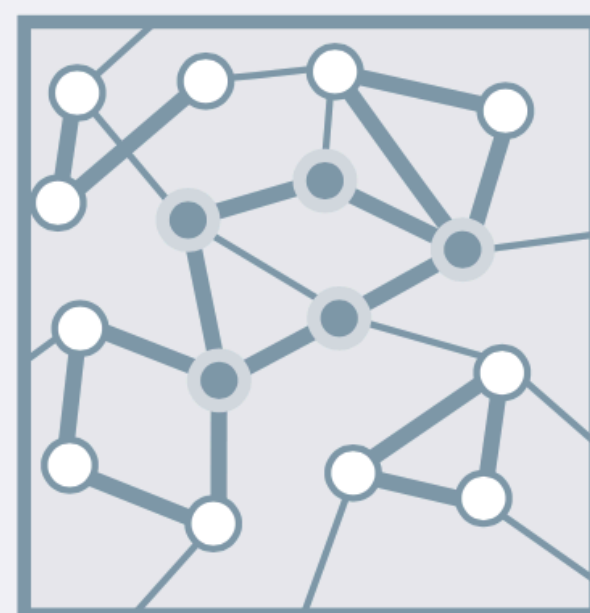
- New concept, active
- Existing concept, active
- Inactive



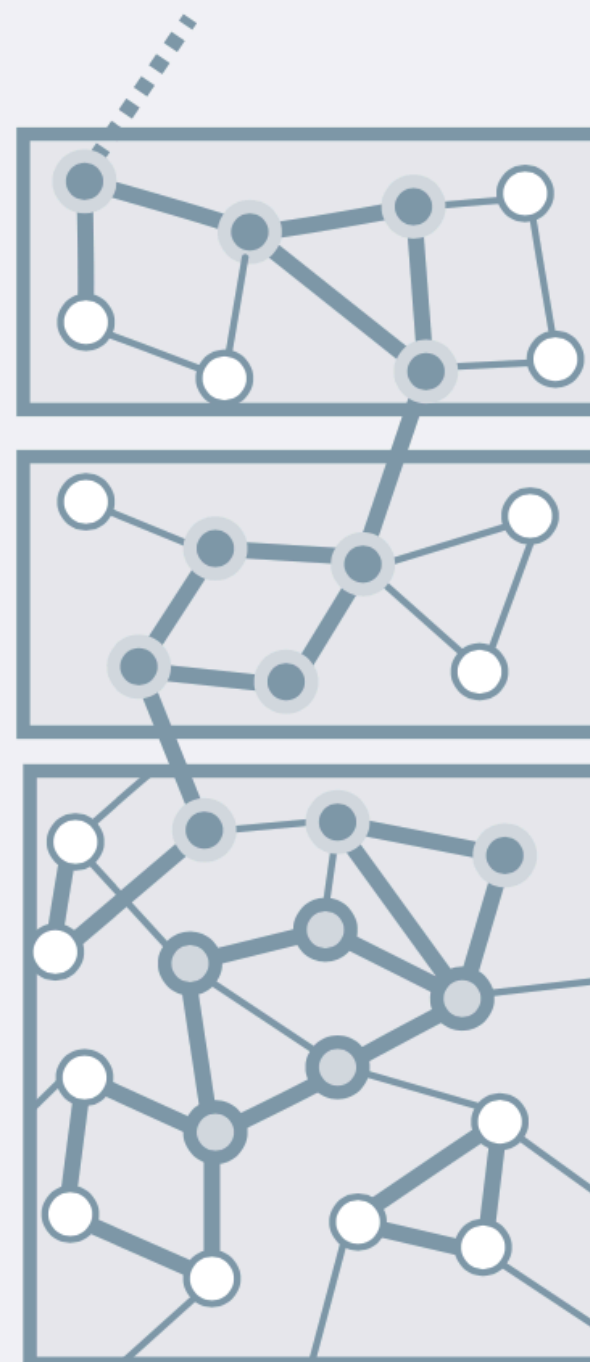
Encoding



Consolidation



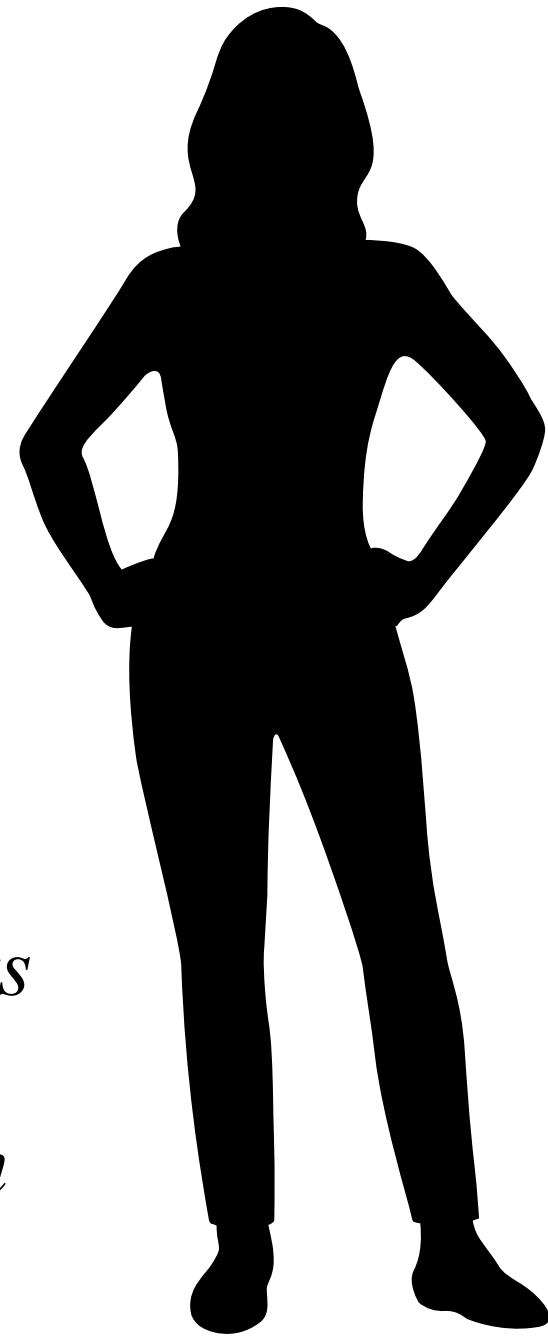
Storage



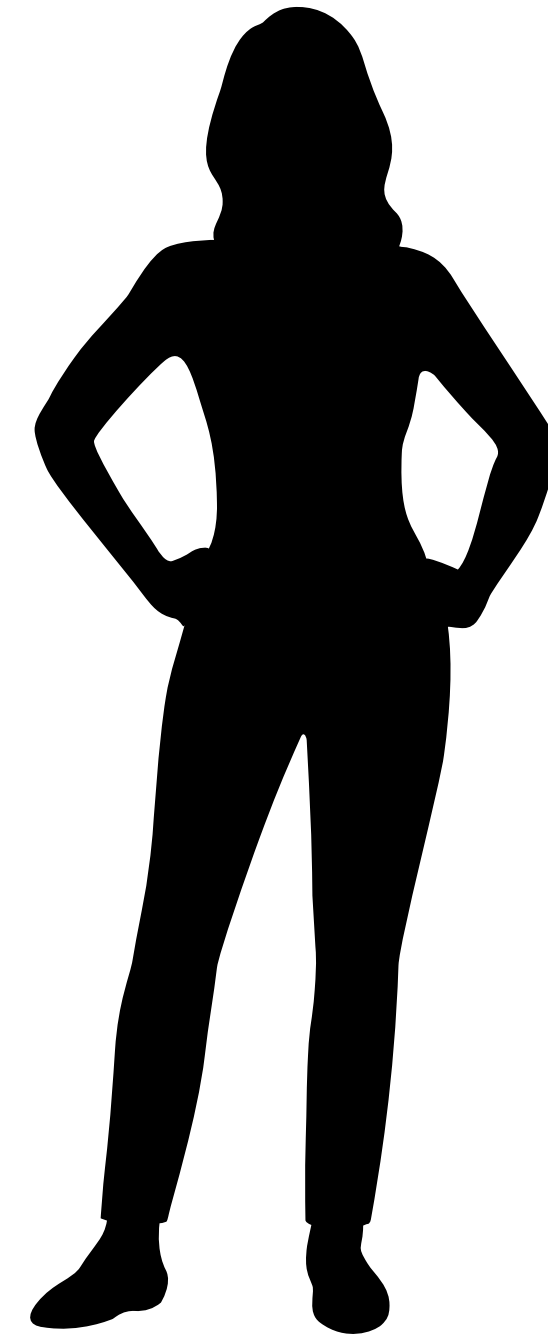
Retrieval

- While learning, under certain conditions, connections between the active neurons are strengthened to create an engram.
- This process takes energy, time, and biological resources, and is required to create a long-lasting engram.
- Having an established network of prior knowledge makes it easier and faster to consolidate new memories.
- After every retrieval attempt, the activated engrams, as well as the activated associations and pathways, stand a chance to undergo reconsolidation.

*“I fully utilize the class hours for the lecturing, students should do the rehearsals on their own after the class”*



**Who is  
more  
effective?**



*“I take breaks during the lectures and do retrieval practices.”*

# Effective Learning Strategies

# Spacing & Interleaving

**Spacing** — Repetitions spaced out over time will lead to greater retention of information in the long run than the same number of repetitions close together in time.



**Interleaving** occurs when different ideas or problem types are tackled in a sequence, as opposed to attempting multiple versions of the same problem in a given study session.

- Students often cram before exams; they can remember the information required for the exam – but not for long.
- Spaced practice and interleaving are harder and less intuitive than cramming, but produce better long-term results.
- Getting students to use spaced practice is really hard. It might be difficult for them to stick to a schedule.

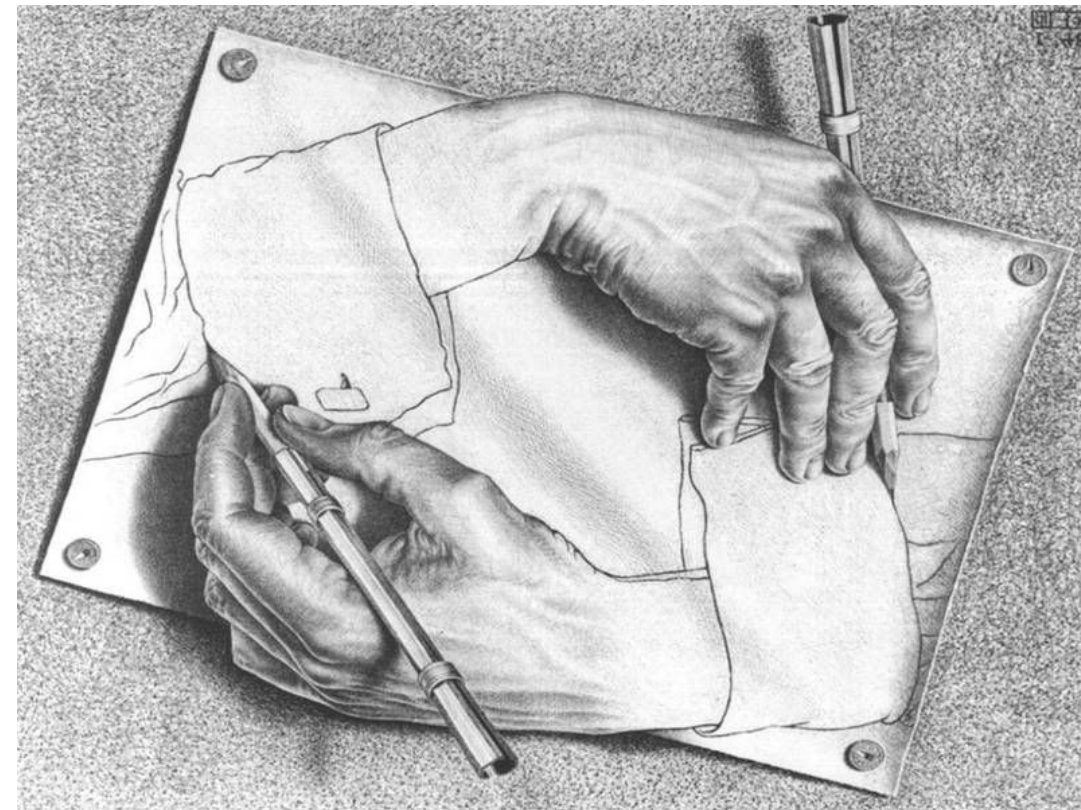
# Spacing & Interleaving in the Classroom



- Give lagged homework, so that students have to do homework on a topic you taught a while back.
- Integrate brief reviews of previous ideas into later classes.
- Give students opportunities to engage with material covered in previous classes – this can be most effectively done with spaced quizzes.
- As a policy, quizzes could cover topics from the beginning always.

# Elaboration, Concrete Examples & Dual Coding

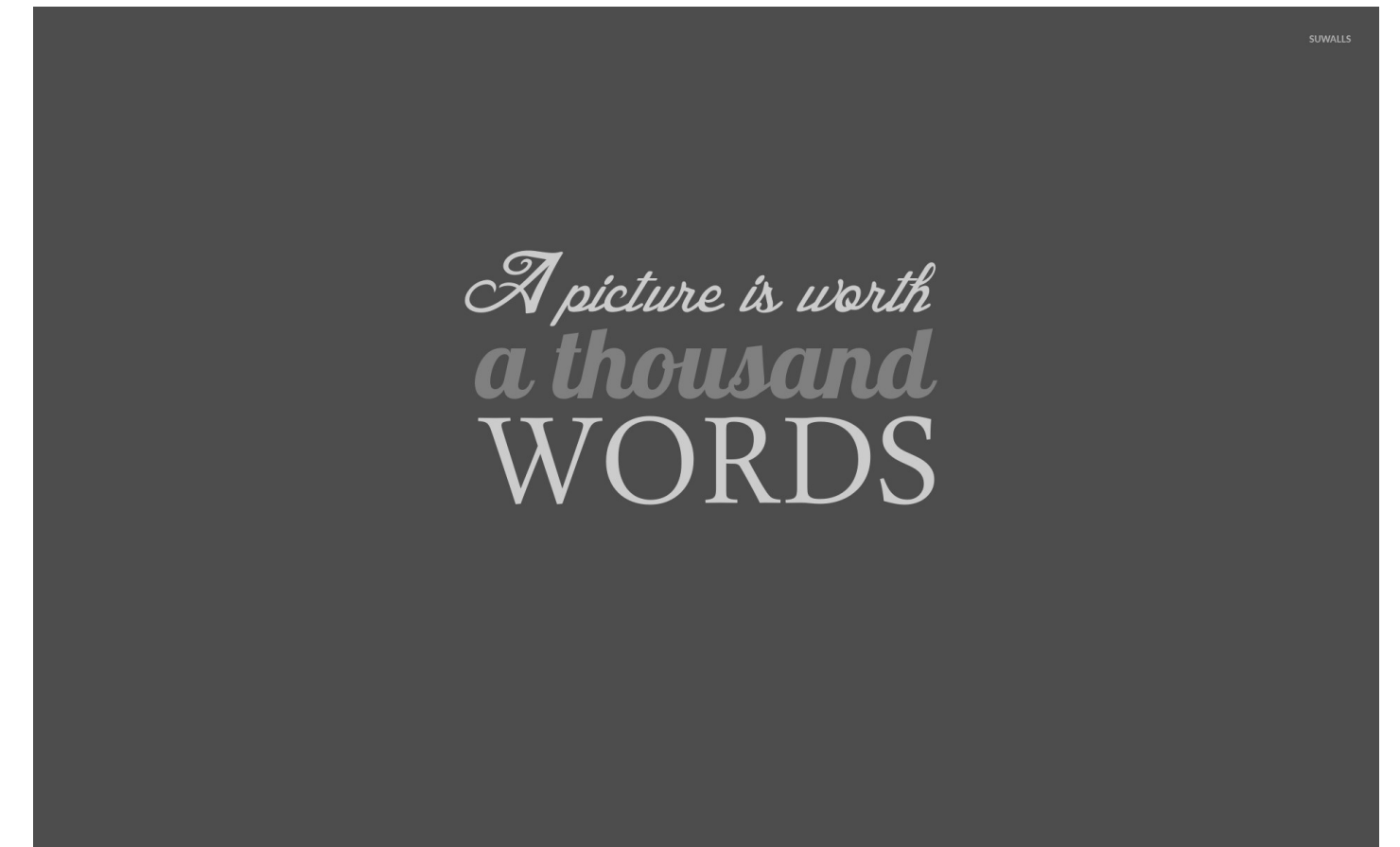
*For understanding to happen, new information needs to be connected to pre-existing knowledge.*



- Elaboration describes the process of adding features to one's memories.
- Understanding can be increased through strategies that promote elaboration.
- Elaborative interrogation involves asking and answering "how" and "why" questions.



- It is important to use multiple concrete examples to illustrate abstract concepts.
- Concrete examples help illustrate abstract ideas and make them easier to understand.



- Combining pictures with words can be helpful for all learners – not just those who like pictures.
- Pictures are generally remembered better than words, and can provide an additional memory cue.
- Any pictures accompanying written material must be relevant to target concepts.

# Elaboration in the Classroom



- To encourage elaboration, help students to come up with relevant “how” and “why” questions about what they are studying.
- You could also ask students questions that explicitly require them to compare and contrast different ideas within the same overall topic : “How are two ideas similar to one another?”, “How are these ideas different from one another?”
- Encourage students to make connections to their own memories or experiences.
- When presenting an abstract concept, use more than one concrete example to explain the idea. Preferably, your examples will differ in terms of surface details, to help students generalise from the example to the idea.
- Use visual examples as well as verbal examples.

# Retrieval Practices

- The act of retrieval itself strengthens memory, making information more retrievable later.
- Retrieval practice gives students feedback on what they know and do not know, and gives teachers feedback too.
- If the goal is long-lasting, durable learning, then retrieval practice is a highly effective learning strategy.
- Retrieval practice doesn't have to be done with a formal test.

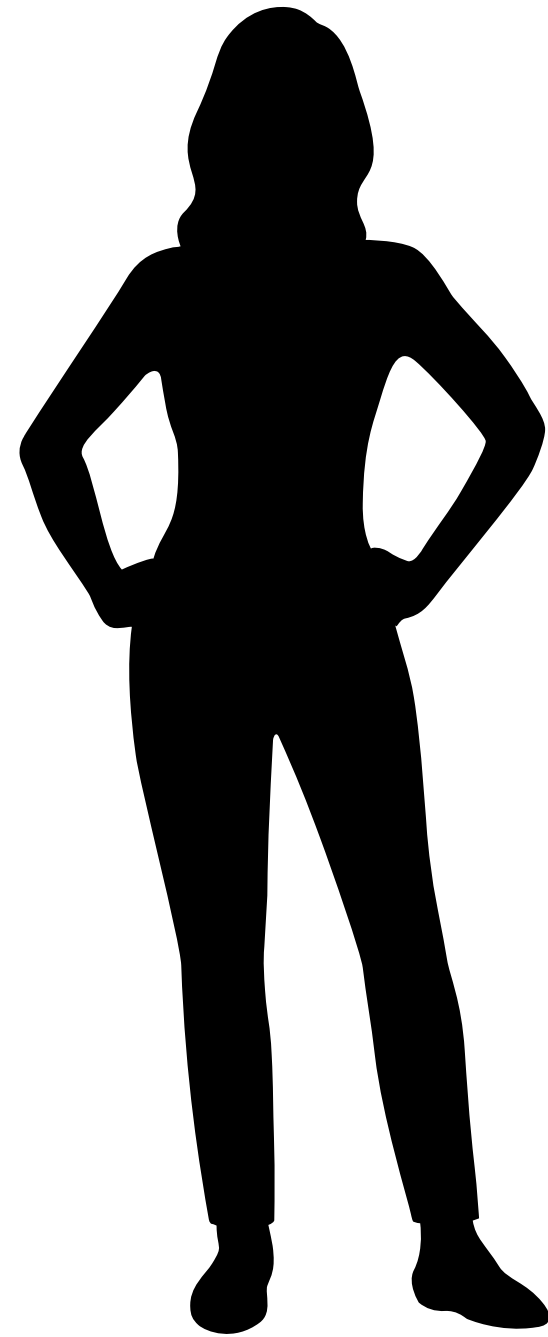


- Teachers can promote retrieval practice in the classroom by giving frequent low- or no-stakes quizzes.
- Any retrieval practice format that teachers can implement in their classrooms is likely to benefit students.
- Scaffolding by giving hints and guides is a great way to help increase retrieval success.
- Retrieval practice can feel difficult, but it's important not to fall into the trap of feel-good learning.

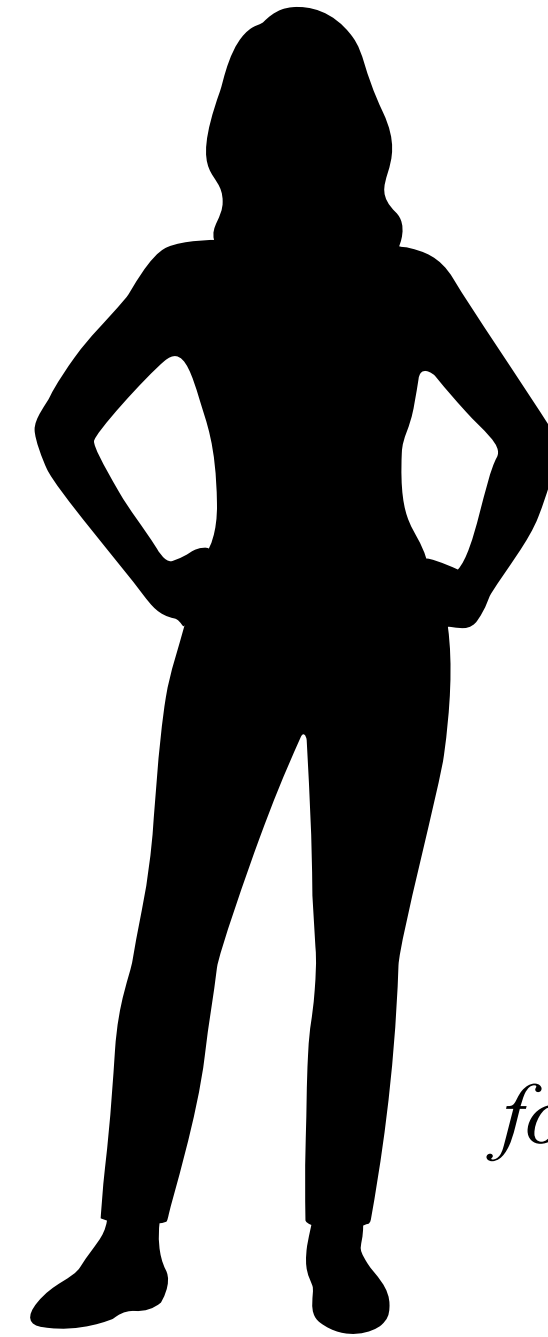
# RECAP

1. **Spaced practice** — Creating a study schedule that spreads study activities out over time.
2. **Interleaving** — Switching between topics while studying.
3. **Elaboration** — Asking and explaining why and how things work. Specifically elaborative interrogation — the “how” and “why” questions.
4. **Concrete examples** — When studying abstract concepts, illustrating them with specific examples.
5. **Dual coding** — Combining words with visuals.
6. **Retrieval practice** — Bringing learned information to mind from long-term memory.

*“Each lecture is outstanding, yet assumes that the content has been taught”*

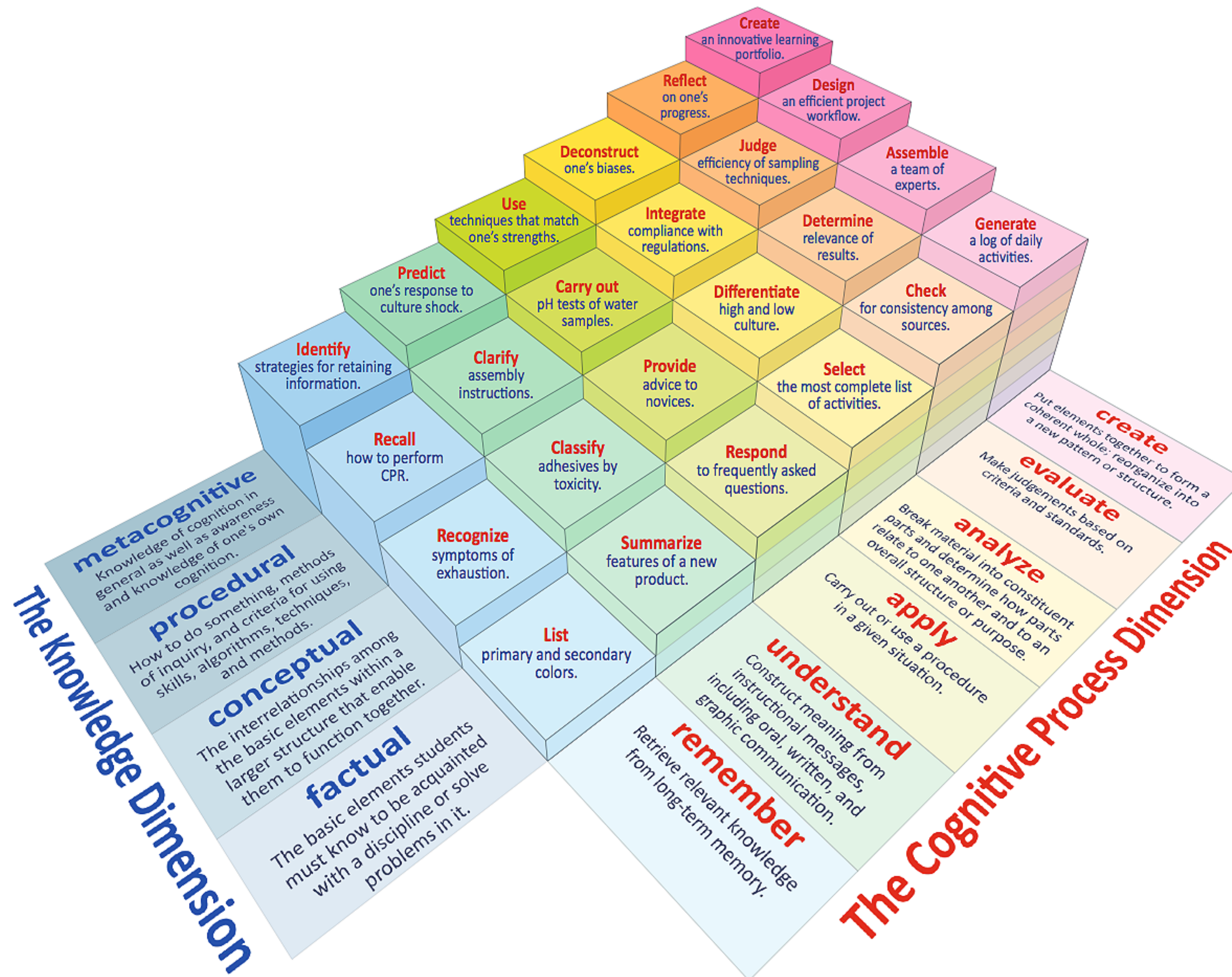


**Who is more effective?**



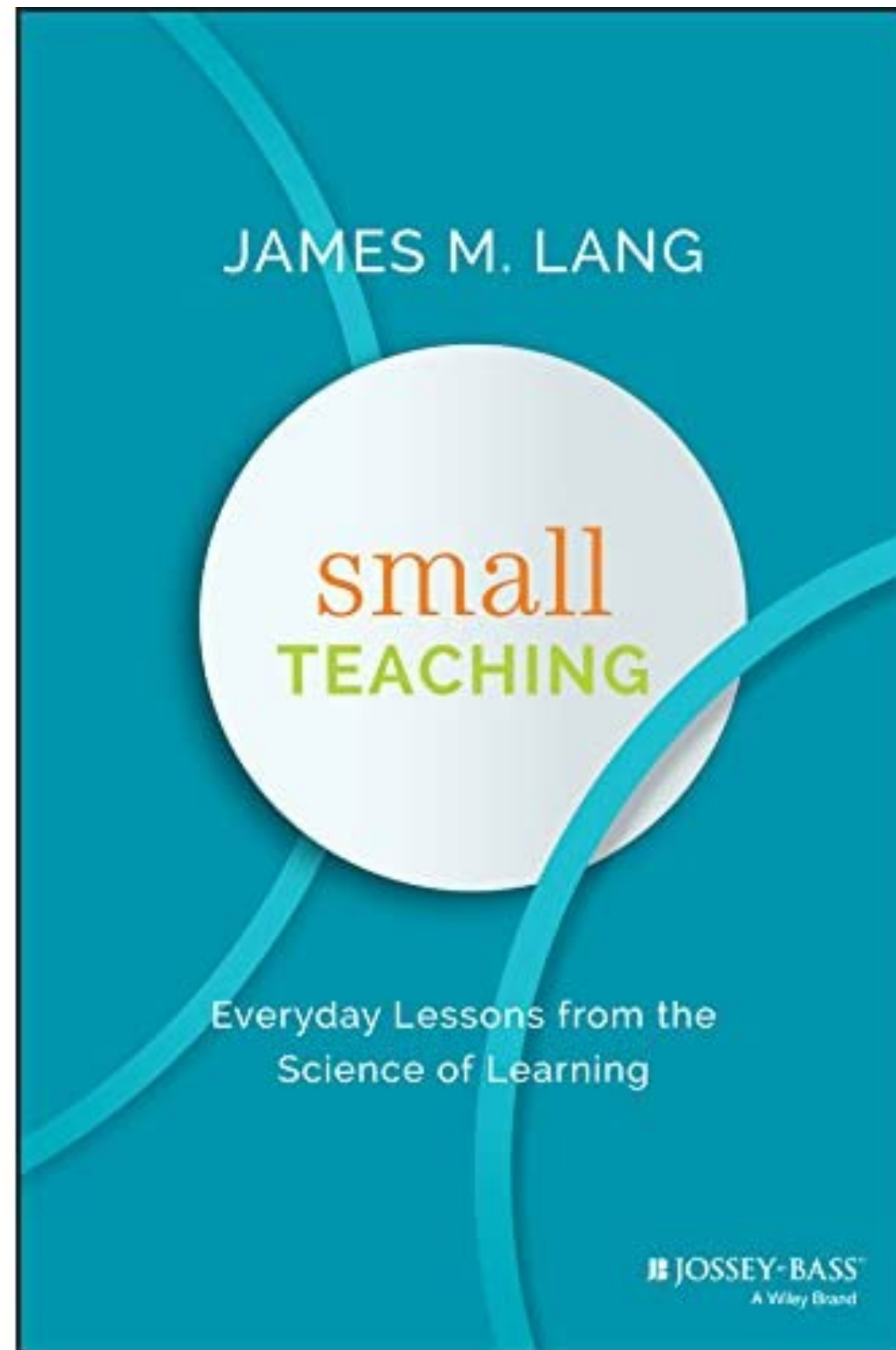
*“Lectures are so-so, but follows strategies to ensure long-term retention”*

# Structured approach to Classroom Instruction



- Employ cognitive skill taxonomies to describe **learning outcomes** of a course. For example, CS101 students should
  - Remember the syntax of Python language*
  - Divide a problem into subproblems*
  - Determine the loop conditions, etc.*
- Apply **evidence-based instructional strategies** in the classroom.
- Develop course **assessment plans**.
- Facilitate student's use of **metacognitive learning strategies**.

# Structured approaches are hard!



**Teaching is not always about huge, programmatic changes; it can also be about incremental modifications.**

*“Much of what we've been doing as teachers and students isn't serving us well, but some comparatively simple changes could make a big difference”.*

***James M. Lang.*** “Small Teaching: Everyday Lessons From the Science of Learning”

# Some Small Teachings



*“Open the class by asking students to remind you of content covered in previous class sessions; allow them to reflect for a few moments if you do so orally.”*



*“At the beginning of a unit give students a brief pretest on the material.”*

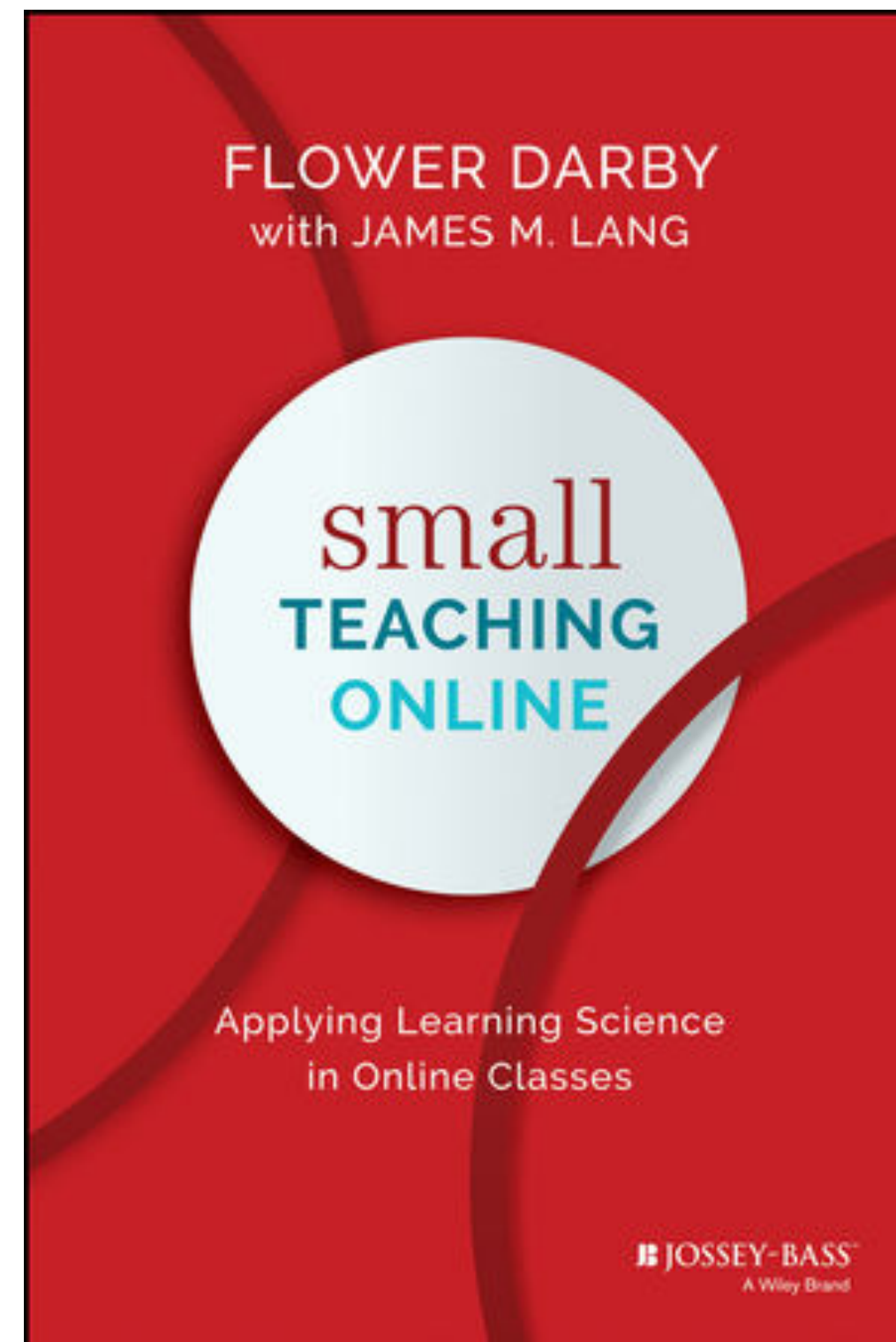


*“Prior to first content exposure, ask students to write down what they already know about that subject matter or to speculate about what they will be learning.”*



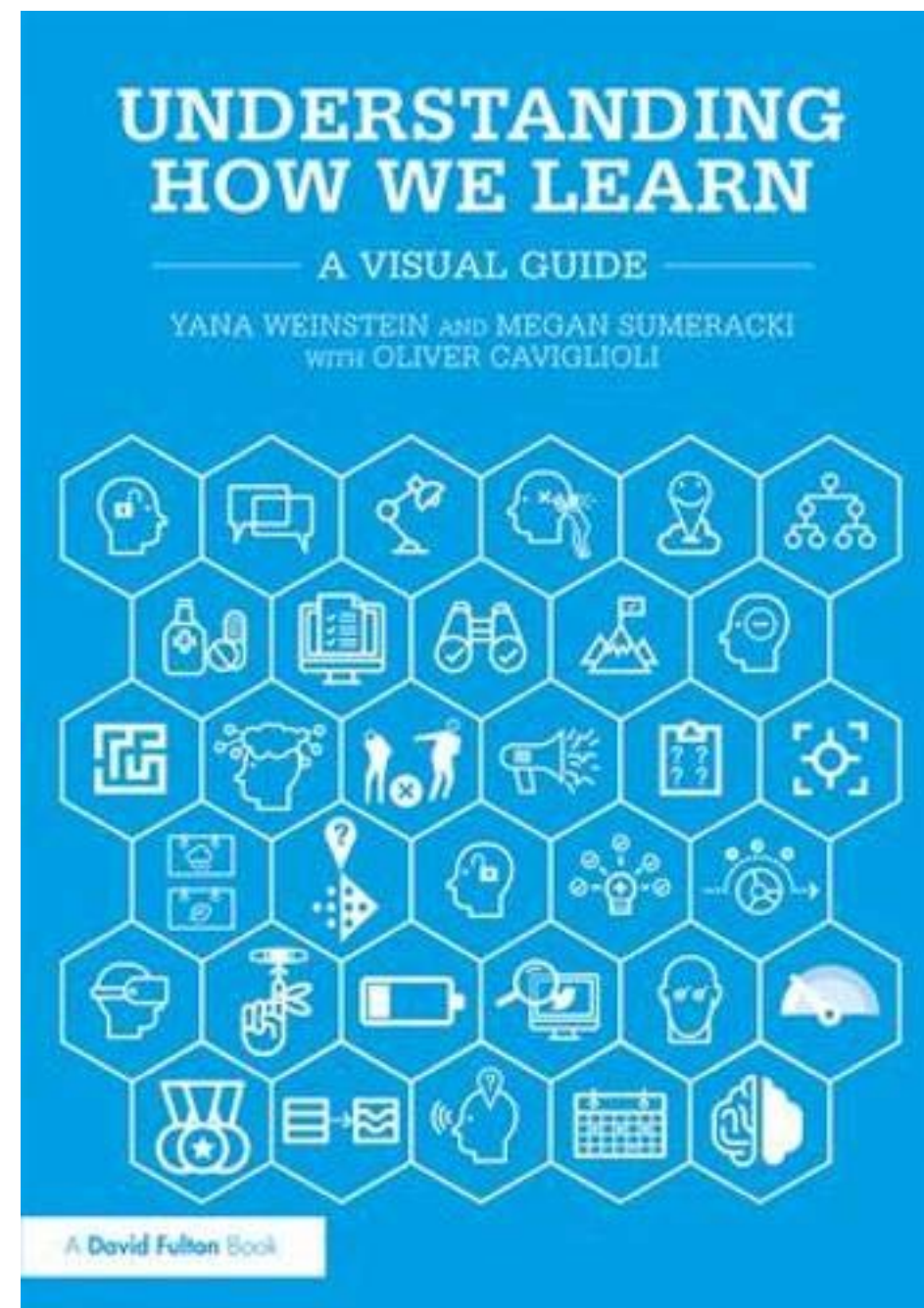
*“Close class by asking students to write down the most important concept from that day and one question or confusion that still remains in their minds ”*

# Small Teaching Online



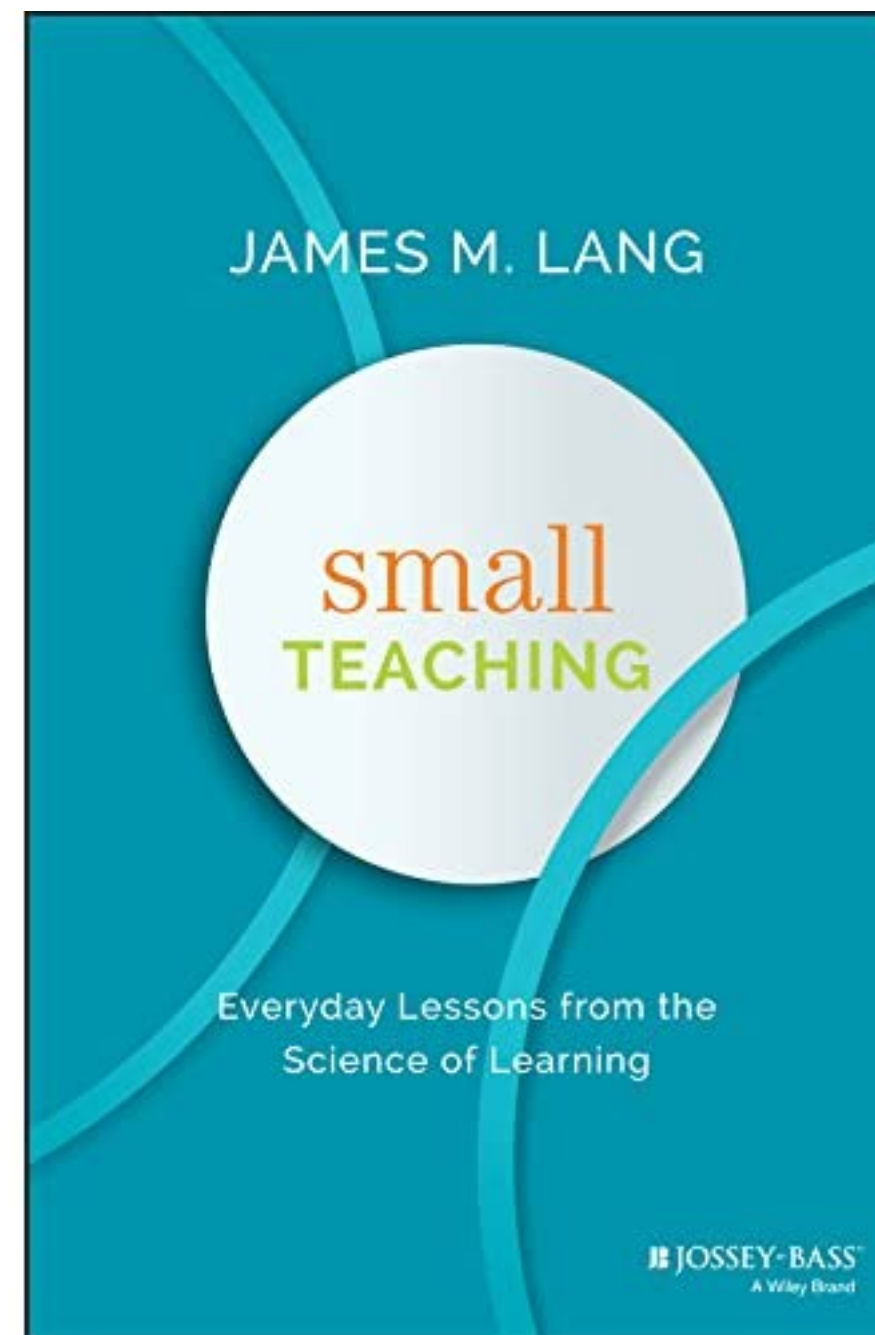
- \* “Create several mini-assignments that become the cumulative assessment in the class”
- \* “Create short, three to five-minute mini-lecture videos.”
- \* “Require peer-to-peer interactions in your class.”
- \* “Look for models and examples of best practice.”
- \* “Add complexity after you build confidence with simple techniques.”

# References



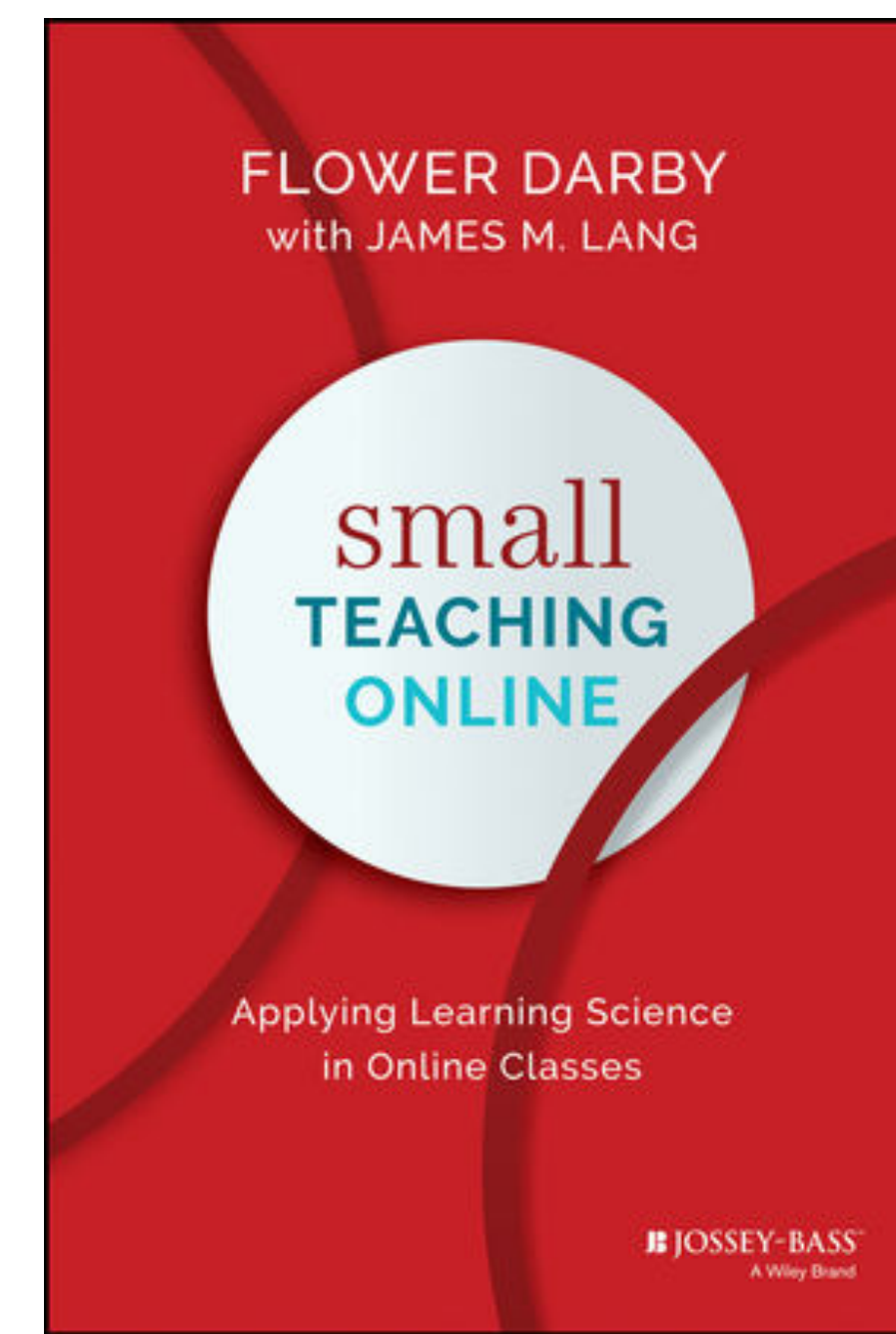
## **Understanding How We Learn: A Visual Guide**

*Yana Weinstein, Megan Sumerack, Oliver Caviglioli*



## **Small Teaching: Everyday Lessons from the Science of Learning**

*James M Lang*



## **Small Teaching Online: Applying Learning Science in Online Classes**

*Flower Darby, James M Lang*