Memory research for the classroom

researchED Durrington
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“Learning involves changes in long-term memory”

A simple model of memory

- **Environment**
  - Attention
  - Remembering
  - Forgotten

- **Working Memory**
  - (site of awareness and of thinking)
  - Learning

- **Long-Term Memory**
  - (factual knowledge and procedural knowledge)

Working memory

A ‘bottle-neck’ to learning

**Limited capacity**

- Involves conscious, effortful thinking
- Around 4 ‘chunks’ of information
- Easily overloaded

**Warning signs include**

- Incomplete recall
- Failure to follow instructions
- Place-keeping errors

Avoid splitting attention

1. The sun’s heat over the oceans evaporates water.
2. Water condenses as clouds.
3. As clouds meet colder air they release the water as precipitation.
4. Water run off forms streams and rivers.
5. Some of the water infiltrates the soil as groundwater.
6. Eventually these rivers and groundwater discharge the water back to the sea.

Use both routes through WM

Prior knowledge actively helps

DWT CPO HAC AOG TOI GPT
DOG CAT PIG COW TOP HAT

Prior knowledge actively helps

<table>
<thead>
<tr>
<th>‘Knowing’ is essential</th>
<th>“Students learn new ideas by reference to ideas they already know”</th>
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<tbody>
<tr>
<td>Helps working memory</td>
<td>“Each subject area has some set of facts that, if committed to long-term memory, aids problem-solving”</td>
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<tr>
<td>Vital for problem solving</td>
<td>Transfer to novel problems (and critical thinking, analysis and evaluation) requires relevant knowledge to be available within long-term memory</td>
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## Implications for teaching...

<table>
<thead>
<tr>
<th>Bottleneck to learning</th>
<th>Break down new learning, introduce only a small number of new ideas at a time.</th>
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<tbody>
<tr>
<td>Avoid splitting attention</td>
<td>With new learning, include labels within a diagram and keep relevant information close to questions</td>
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<tr>
<td>Two routes through WM</td>
<td>Use a relevant image when giving an explanation. Avoid using the same ‘channel’ twice for different information.</td>
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<tr>
<td>Prior knowledge actively helps</td>
<td>Identify the foundational knowledge (e.g. key vocabulary, key concepts and facts) and help pupils recall them reliably.</td>
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Long-term memory

## Organised as schemas

### What are schemas?
A **framework** or **mental plan** that helps organise and interpret information and deal with new experiences.

### Helps working memory
Requires **minimal mental effort** to apply a schema. Allows information to be grouped into ‘chunks’.

### Thinking, fast
Thinking based on schemas is **quick and effortless** but more **influenced by bias** and misconceptions.

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A father and his son are out driving and are involved in a terrible accident. The father is killed instantly, and the son is in critical condition. The son is rushed to the hospital and prepared for an operation that could save his life.

The surgeon comes in, sees the patient, and exclaims, “I can’t operate, that boy is my son!”

Who is the surgeon?
Organised semantically

What’s the **difference in the thinking** which goes on when completing a **word search** compared to a **crossword**?
Novices and experts think differently

**Novices’ explanation for their grouping of two problems**

- Problem 7 (23)
  - Blocks on inclined planes with angles.

**Experts’ explanation for their grouping of two problems**

- Problem 7 (35)
  - K=200 N/m
  - 6m
  - 15m

“Conservation of energy.”

# Novices and experts think differently

<table>
<thead>
<tr>
<th>Learning new information</th>
<th>Novices lack the schemas to easily integrate new information</th>
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<tr>
<td>Experts notice features and meaningful patterns of information that novices don’t</td>
<td></td>
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</table>

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<tr>
<th>Organisation of memory</th>
<th>Novices' memories are organised differently than experts'</th>
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<tr>
<td>Experts have knowledge that is organised to reflect a deep understanding of their subject matter</td>
<td></td>
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</table>

| Problem solving                                               | Novices tend to approach problems based on their superficial features |
|---------------------------------------------------------------|Experts’ schemas allow them to flexibly retrieve important aspects of their knowledge with little effort |


Linking abstract and concrete representations

Rule is: If there is a ‘D’ on one side of the card, there must be a ‘3’ on the other.

Which cards do you need to flip to test this rule?

Rule is: If the person is having a beer, they must be over 18.

Which drinkers would you check to ensure no underage drinkers?

### Implications for teaching...

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<th><strong>Thinking fast</strong></th>
<th>Misconceptions may ‘activate’ readily unless new conceptions are well practised</th>
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<tr>
<td><strong>Semantically organised</strong></td>
<td>Choose activities which help pupils focus their thinking on the meaning of material</td>
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<tr>
<td><strong>Novices and experts</strong></td>
<td>Don’t necessarily expect pupils to learn science, history, etc through the methods used by expert scientists, historians, etc</td>
</tr>
<tr>
<td><strong>Abstract vs Concrete</strong></td>
<td>Link abstract concepts with concrete examples; fade out the concrete examples over time</td>
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Forgetting

Practice makes permanent

Each time we return to that material, it is:

- Relearnt quicker
- Retained for longer


Space out practice

Spread out opportunities to review key vocabulary, concepts and facts

- more effective than ‘cramming’

![Graph showing mean number of items recalled on initial and final tests for massed and spaced groups](image)

Fig. 1. Mean number (out of 20) of items recalled on initial and final tests for massed and spaced groups (from Bloom & Shuell, 1981).

Retrieval practice helps learning

Testing improves long-term recall

- Low-stakes quizzing
- Shouldn’t be stressful
- Spaced out over time

Fig. 3. Performance on immediate and delayed retention tests after learning text passages (from Roediger & Karpicke, 2006b).

### Implications for teaching ...

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<th>Implication</th>
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<tr>
<td>New learning rapidly decays</td>
<td>‘Lightbulb’ moments are great, but don’t let them fool you! Learning is more incremental than transformational</td>
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<tr>
<td>Practice makes permanent</td>
<td>Reassure pupils who ‘forget’ that the learning is never wasted</td>
</tr>
<tr>
<td>Space out practice</td>
<td>Build opportunities to review past learning into your schemes of work and curriculum planning</td>
</tr>
<tr>
<td>Retrieval practice helps learning</td>
<td>Low-stakes testing opportunities will help pupils recall learning more reliably over time</td>
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Six ‘good bets’ for the classroom

Helping students take in new information

Pairing graphics with words

We all receive information through **two primary pathways**
- auditory (for the spoken word) and
- visual (when reading or for graphical representations).

Exploit these paths through working memory by **using a relevant image / flow chart / diagram to support verbal explanations** of new ideas.
Helping students take in new information

Link abstract concepts with concrete representations

Teachers should present tangible examples that illuminate overarching ideas and also explain how the examples and abstract ideas connect.

We all find abstracts hard. Interleaving and ‘concreteness fading’ can help students to transfer learning to new contexts.
Helping students connect information

Repeatedly alternate problems with their solutions and problems students must solve

*Explanations accompanying solved problems* help students comprehend underlying principles, taking them beyond the mechanics of problem solving.

*Worked examples* and *partial solutions* can provide scaffolding and reduce the load on working memory.
Helping students connect information

Posing probing questions

Asking students “why,” “how,” “what if,” and “how do you know” requires them to clarify and link their knowledge of key ideas.

Encourage effortful thinking about the meaning of new material. (semantic level processing)
Helping students retain learning

Distributing practice

Students should practice material several times after learning it, with each practice or review separated by weeks and even months.

Consider using ‘cumulative’ rather than modular assessments of learning
Helping students retain learning

Assessing to boost retention

Assessments that require students to recall material helps information “stick” in long-term memory.

Use frequent low-stakes quizzes and tests, and encourage this as a revision strategy to foster independent learning.
Where can I read more?