The Science of Memory: What We Know, and How to Help Students Study Better

Kevin Yee | FCTL
Learning Styles? Learning Pyramid?

Source: National Training Laboratories, Bethel, Maine
Random Controlled Trials

Population is split into 2 groups by random lot

Outcomes for both groups are measured

Intervention

Control
Guess!

- distributed practice
- elaborative interrogation
- highlighting (or underlining)
- imagery use for text learning
- interleaved practice
- keyword mnemonic
- rereading
- practice testing
- self-explanation
- summarization
<table>
<thead>
<tr>
<th>Technique</th>
<th>Utility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elaborative interrogation</td>
<td>Moderate</td>
</tr>
<tr>
<td>Self-explanation</td>
<td>Moderate</td>
</tr>
<tr>
<td>Summarization</td>
<td>Low</td>
</tr>
<tr>
<td>Highlighting</td>
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<td>The keyword mnemonic</td>
<td>Low</td>
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<td>Imagery use for text learning</td>
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<tr>
<td>Rereading</td>
<td>Low</td>
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<tr>
<td>Practice testing</td>
<td>High</td>
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<tr>
<td>Distributed practice</td>
<td>High</td>
</tr>
<tr>
<td>Interleaved practice</td>
<td>Moderate</td>
</tr>
</tbody>
</table>
The Science of Memory

Image: Scipro/Gett

Image: Times Higher Ed
“Brain-Based” Publications


Principles

A
N
S
W
E
R
Principles

Attention
N
S
W
E
R
ATTENTION

Image: https://www.canstockphoto.com/illustration/five-finger.html
• Dollar bill
• Dice
• Tricycle
• Four-leaf clover
• Hand
• Six-pack
• Seven-up

• Octopus
• Cat lives
• Bowling pins
• Football team
• Eggs
• Friday
• Valentine’s day
• Dollar bill
• Dice
• Tricycle
• Four-leaf clover
• Hand
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• Seven-up

• Octopus
• Cat lives
• Bowling pins
• Football team
• Eggs
• Friday
• Valentine’s day
Working Memory

LIMITED

CAPACITY
What about multi-tasking?
How long can the average first year student pay attention?

- 5 minutes
- 10 minutes
- 15 minutes
- 30 minutes
- 60 minutes
Attention

Time
Principles

Attention

Novelty

S

W

E

R
Safe Environment
SEEMS LEGIT.

More from around the Web
9 Ways to Get Rich Quick

I CAN'T BELIEVE IT!
This Outrageous Truth About Green Gummy Bears Will Destroy Your World
You think you have life figured out, and then, BAM!

Man Tries to Hug a Wild Lion, You Won't Believe What Happens Next!
Principles

Attention
Novelty
Spacing
W
E
R
SPACING: Distributed Practice
Why do students cram?
Working Memory
Limited Capacity

Encoding

Long-Term Memory
UNLIMITED Capacity
Interleaved (Mixed) Practice
Interleaving

Spacing Effect + Interleaving = ?
Spacing Effect + Interleaving = Ongoing Cumulative Testing
Principles

Attention
Novelty
Spacing
Why
E
R
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Context

- Concept maps
- Mind maps
- Flow charts
- Examples
- Elaboration

Image: Leidy Klotz
Principles

Attention
Novelty
Spacing
Why
Emotion
R
Limbic System

- hippocampus
- thalamus
- amygdala

Image: http://audrageras.com
JK Rowling's revenge: Harry Potter author reveals she based one of her most evil characters on a teacher she hated at school

- JK Rowling said hated character was based on a teacher from school days
- She did not reveal the identity of woman who inspired Dolores Umbridge
- But she said she disliked the teacher on sight because of twee accessories
What can YOU do to create positive emotions in class?

Image: Averett.edu
Principles

Attention
Novelty
Spacing
Why
Emotion
Retrieval
Working Memory

Encoding

Retrieval

Long-Term Memory

FILTER
Interrupting the Forgetting Process
Interrupting the Forgetting Process

LEARNING IS EFFORTFUL!
Nicholas Carr, *The Shallows* (2011)
Principles

Attention
Novelty
Spacing
Why
Emotion
Retrieval
Changes to Syllabi

• Policy against laptop use (?)
• Set context for why this class is important and relevant to their future
• Link students to study skills materials (see below)
• Humanize and introduce the instructor to increase approachability and likability
Changes to Course Design

• Cumulative assessment structure
• Frequent quizzes
• Include unannounced quizzes
• Intentional interleaving within quizzes
• Implement flipped (or “scrambled”) design
Changes to Lesson Plans

• Cold-call on (some?) students without raised hands
• Use first and last minutes of class wisely
• Make students guess before giving answers
• Do not distribute PPT slides
• Present lectures in chunks and include attention resets
• 280 Interactive Techniques (CATs): http://bit.ly/interactivetechniques (example on next slide)
104. **Pair-Share-Repeat** – After a pair-share experience, ask students to find a new partner and debrief the wisdom of the old partnership to this new partner.

105. **Teach-OK** – The instructor briefly explains a concept. The teacher then says “teach!”, and the students respond “OK!” Students then form pairs and take turns re-teaching the concept to one another.

106. **Wisdom of Another** – After any individual brainstorm or creative activity, partner students up to share their results. Then, call for volunteers of students who found their partner’s work to be interesting or exemplary. Students are sometimes more willing to share in plenary the work of fellow students than their own work.

107. **Secret-Write and Reveal** – Students individually write down a guess on a prompt given by the teacher, but keeps the answer hidden from partner. Then, everyone reveals and discusses why they had different answers.

108. **Human Flashcards** – Students take turns calling out terms they were expected to memorize, and demand an answer from their partner.

109. **Storytelling Gaps** – One partner relay a story that summarizes learning in the chapter so far, but leaves out crucial fine information (such as dates that should have been memorized). The partner listens and records dates silently on paper as the story progresses and then updates the first person.

110. **Do-Si-Do** – Students do partner work first, then sound off by twos. All of the 2’s stand up and find a new partner (the 1’s are seated and raise their hands until a new partner comes), then debrief what was said with the first partner. Variation: Later, all the 1’s come together in a large circle for a group debrief, while the 2’s have their own circle.

111. **Forced Debate** – Students debate in pairs, defending either their preferred position or the opposite of their preferred position. Variation: Half the class takes one position, half the other. The two halves line up, face each other, and debate. Each student may only speak once, so that all students on both sides can engage the issue.
But what about students’ burden?

Image: Economic Times
See especially the downloadable posters:
https://www.learningscientists.org/s/All-Color-Posters-gsaw.pdf
Principles

Attention
Novelty
Spacing
Why
Emotion
Retrieval

[Diagram with arrows pointing to "focused Attention", "active Thinking", and "spaced Repetition"]
Study Skills Tips

https://bit.ly/Yee-Study-Skills
24. **Always take notes, even in classes that don’t seem to demand it.** There is a well-known phenomenon called the “illusion of mastery” that occurs when students hear an expert explain advanced concepts. During the expert’s explanation, students have no questions and thus may not take notes, but many struggle to recreate the skill, logic, or knowledge once away from the expert. Resist the temptation to assume it will be equally obvious later, and record notes during the lecture.

25. **Balance note-taking and careful listening.** Because the brain can’t truly do two things at one time, any time you spend writing notes will mean reduced attention to the continuing lecture. But notes are important not only for later studying; they also help with starting the process of storing memories. The mere act of taking notes on things that you see, hear, and think creates associations in the brain, and since memories are associative, the taking of notes will improve recall over just listening even if the notes are not looked at later (but they **should** be looked at!)

26. **Take notes for studying, not for comprehensiveness.** Instead of taking notes that try to capture EVERYTHING, aim to take notes which can encourage later recall. That might mean a focus on concepts and definitions, or perhaps formulas. Faculty seldom pack all relevant information into the lectures; the reading covers many important ideas as well. Your job is to record the connections, context, and connotations that are not obvious in the reading. Of course, you need to have done the reading ahead of time!

27. **Take notes FAR beyond what’s displayed on screen.** Simply capturing the displayed words accurately will often not be enough to jar your memory about the crucial steps, relationships, and concepts discussed while these words were displayed. Take notes that capture the lecture and discussion as well as the slide content.