Making Learning Stick: Evidence Based Techniques to Improve Instruction and Student Learning

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• “Need More Classroom Experiments”

• “Stop Lecturing Me” (Scientific American, 2014)

Importing basic learning and memory techniques into classrooms may require only minor adjustments
Kaplan Test Prep and Admissions Survey
How are students studying?

1. Survey of Washington University psychology students (177) (Karpicke et al., 2009, Memory)

- 84% reread notes or textbook
- 55% rate rereading as their #1 study activity
Rereading Psychology Textbook Chapters

Experiment:

➢ Students read textbook chapters either once or twice.

➢ Students were given a test consisting of 22 multiple choice questions and 4 short-answer questions requiring explanation.

Callender & McDaniel (2009, Contemporary Educational Psychology)
Results
Abnormal Psychology

Immediate Test

Percent Correct

- Multiple Choice
- Short Answer

Read Once
Read Twice
Results
Abnormal Psychology

Delayed Test

![Bar chart showing the results for multiple choice and short answer questions with 'Read Once' and 'Read Twice' categories. The chart indicates that 'Read Twice' has a higher percent correct for both multiple choice and short answer questions.]

- Multiple Choice
  - Read Once: 70%
  - Read Twice: 60%
- Short Answer
  - Read Once: 20%
  - Read Twice: 25%
Results

Biopsychology Chapter

Immediate Test

<table>
<thead>
<tr>
<th>Percent Correct</th>
<th>Read Once</th>
<th>Read Twice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple Choice</td>
<td></td>
<td></td>
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<tr>
<td>Short Answer</td>
<td></td>
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</tbody>
</table>

- Red: Read Once
- Blue: Read Twice
Results
Biopsychology Text

Delayed Test

Multiple Choice
Read Once
Read Twice

Short Answer
Percent Correct
0 10 20 30 40 50 60 70 80 90 100
Multiple Choice
Short Answer
Favored study methods of many undergraduates are not especially potent.

If Not Rereading, Then What Techniques Are Desirable?
Perspective from Cognitive Psychology

➢ To students, new information to be learned is arbitrary
The short man bought the broom
The brave man gave the money to the robber
The fat man read the sign
The tall man bought the crackers
1. Generate Understanding
Build understanding by generating a reason

The hungry man got into the car ... to go to the restaurant.

The brave man ran into the house ... to save the boy from the fire.


Try to explain: Answer WHY? (Or other “deep-level” questions such as HOW?, WHAT-IF?)
Chewing mixes food with saliva. This fluid contains an enzyme (salivary amylase), a buffer (bicarbonate, or $\text{HCO}_3^-$), mucins, and water. Salivary glands, beneath and in back of the tongue, produce and secrete saliva through ducts to the free surface of the mouth’s lining. Salivary amylase breaks down starch. The $\text{HCO}_3^-$ helps maintain the mouth’s pH when you eat acidic foods. Modified proteins called mucins help form the mucus that binds food into a softened, lubricated ball (bolus) (Starr, 2000, p. 603).

• Smith et al (2010)
Saliva must mix with food to initiate digestion. Why is this true?
RESULTS

– Standard learning (reread) group: 69%

– Why question group: 76%
Other Techniques to Generate Understanding

1. Have Student Teach or Prepare to Teach Someone Else
   (Fiorella & Mayer, 2014; Nestojko, 2014)

2. Write to Learn (in class mini-writing)

   Even after encoding information well it is sometimes forgotten. 1. Draw the forgetting curve. 2. Explain (in writing) your drawing to someone who has never heard of it. Why does it have this particular shape?
   (Gingerich et al., 2014, Teaching of Psychology)
2. Space study and instruction
Medical School Study

Training in microsurgery for 38 surgical residents

- Videos, practice (microvascular surgery on a synthetic artery model)

Massed (19)—4 training sessions in one day

Spaced (19)—4 training sessions/once a week

Moulton et al. (2006, Annals of Surgery)
Results

Retention (microsurgical drills)
Spacing better than massed one month later
Transfer (aortic anastomosis on anesthetized rat)

% Failing at Surgery

- Massed: 30%
- Spaced: 0%
Spanish

Percent Correct

End of Semester | 1 Month Delayed

Massed | Personalized Spaced

Lindsey et al. (2014, Psychological Science)
3. Mix—Don’t Block

Math: Blocking of problem types

Arrange the terms in ascending order in powers of $x$:

1. $-5x + 3x^5 + 4x^2 - 2$
2. $-6xy + x^4 + 3x^3 + 12$
3. $3xy^2 + x^3y^3 + 6x^2 - 15$

Arrange the terms in descending order in powers of $x$:

4. $-6x + x^5 + 4x^3 - 20$
5. $5x^5 - 9x + 6$
6. $9x - 10 + 8x^3$

Find each sum or difference:

1. $(9 + 4a + a^2) - (8 + 2a + 14a^2)$
2. $(d^2 - d + 5) - (2d + 5)$
3. $(5x^2 - x - 7) + (2x^2 + 3x + 4)$
Math

Students learn to compute volumes of four types of solids

**Blocked**: Instruction + practice problems on each solid in turn

**Mixed**: Instruction on all solids; mixed practice

Final test on 8 novel problems one week after instruction

Taylor & Rohrer (2010, Applied Cognitive Psychology)
Taylor & Rohrer (2010, Applied Cognitive Psychology)
Nine 7th Grade Math Classes (3 teachers)

Two Types of Problems:

Graph problems \( y = 2x - 1 \)

Slope problems \( (1, 5) \) and \( (8,9) \)

Rohrer, Dedrick, & Stershic (2015, Journal of Educational Psychology)
Massed Practice
Shuffled Practice
Experiment 1a and 1b Results

Kornell & Bjork (2008, Psychological Science)
Subjective impressions

78% of learners indicated they learned as much or more with massed than shuffled presentations.
4. Retrieval Practice – Quizzing
"I dreamed I was being chased by a giant standardized test."
Quiz Item
During the months when there is a large amount of pollen in the air, your hay fever severely affects your sense of smell. At the same time your food all seems to taste the same. This illustrates the importance of:
A) serial processing.
B) accommodation.
C) sensory adaptation.
D) sensory interaction.

Exam Question on Sensory Interaction
With her eyes closed and her nose plugged, Chandra was unable to taste the difference between an onion and a pear. Her experience best illustrates the importance of:
A) sensory interaction.
B) kinethesis.
C) sensory adaptation.
D) accommodation.

Indirect Effects of Testing (Quizzing)

• Testing encourages more frequent study
• Quizzing reduces test anxiety
• Testing increases metacognitive accuracy
• Testing improves study effectiveness
Take-Home Points

• Rereading—not necessarily effective

• Help students build understanding (e.g., answer WHY?, study to teach, mini-writings)

• Encourage spacing of material and of studying

• Intermix related concepts/problems during homework

• Quiz—Quiz—Quiz
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Thank you!

Questions?
make it stick

The Science of Successful Learning

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Henry L. Roediger III
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