THE TEACHING CENTER

APPLYING COGNITIVE SCIENCE TO TEACHING: INTERLEAVING, INTEGRATING VISUALS, AND RESETTING ATTENTION

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Key Ideas

1. Interleave content
2. Design instruction to maximize learning and retention
   - Connect new knowledge to prior knowledge
   - Introduce concepts both visually and verbally
   - Help students select and organize information in working memory
3. Reset and refresh attention

Interleave content

Blocking

Presentation order

Learn Volume—**Wedge**

Examples:

1. **Wedge** Problem
2. **Wedge** Problem

Learn Volume—**Spheroid**

Examples:

1. **Spheroid** Problem
2. **Spheroid** Problem

Learn Volume—**Half Cone**

Examples:

1. **Half Cone** Problem
2. **Half Cone** Problem

Homework order

Learn Volume—**all three shapes**

Practice:

1. **Wedge** Problem
2. **Wedge** Problem
3. **Wedge** Problem
4. **Spheroid** Problem
5. **Spheroid** Problem
6. **Spheroid** Problem
7. **Half Cone** Problem
8. **Half Cone** Problem
9. **Half Cone** Problem

Blocking vs Interleaving

Blocking

Learn Volume—**all three shapes**

Practice:

1. **Wedge** Problem
2. **Wedge** Problem
3. **Wedge** Problem
4. **Spheroid** Problem
5. **Spheroid** Problem
6. **Spheroid** Problem
7. **Half Cone** Problem
8. **Half Cone** Problem
9. **Half Cone** Problem

Interleaving

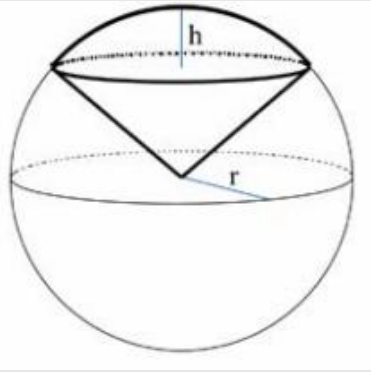
Learn Volume—**all three shapes**

Practice:

1. **Wedge** Problem
2. **Spheroid** Problem
3. **Half Cone** Problem
4. **Spheroid** Problem
5. **Half Cone** Problem
6. **Wedge** Problem
7. **Spheroid** Problem
8. **Wedge** Problem
9. **Half Cone** Problem

Interleaving Study

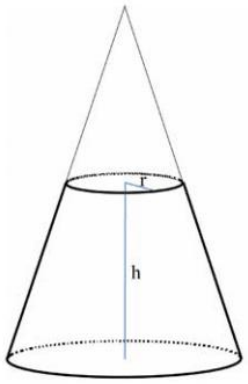
- Learn about volume of 4 more obscure geometric solids (ones on which students would not have prior knowledge)
- 18 undergraduates were separated into two groups (mixers and blockers)
  - Blocked: Instruction + practice problems on each solid in turn
  - Interleaved (mixers): Instruction on all solids; interleaved practice
- Tutorials, practice problems, and test were the same for both groups
- Time on task was the same for both groups



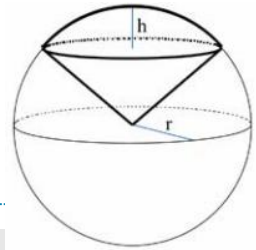
Rohrer, D., & Taylor, K. (2007). The shuffling of mathematics problems improves learning. *Instructional Science*, *35*(6), 481-498.

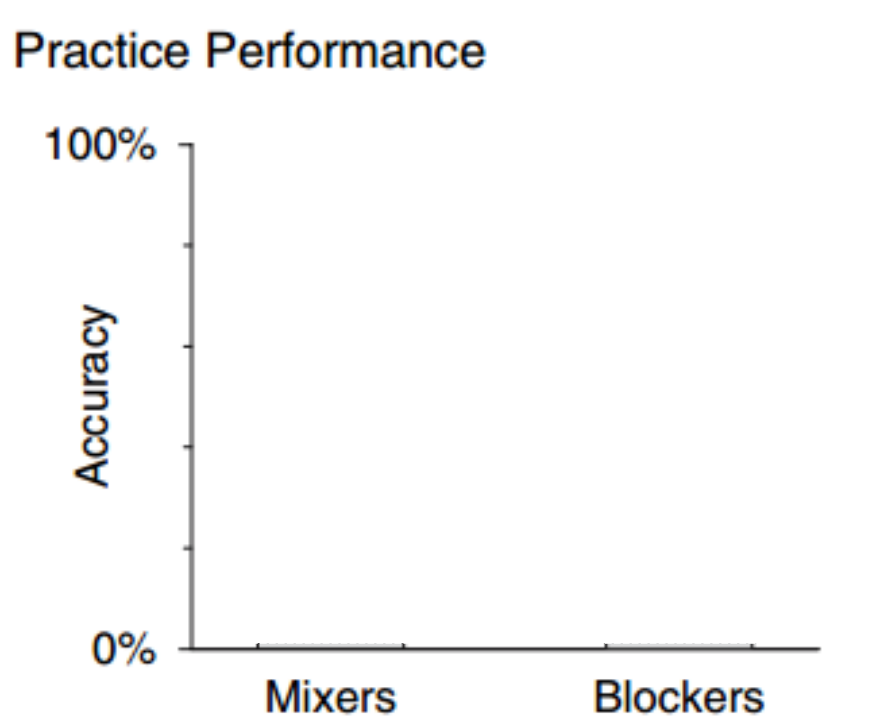
Study Design

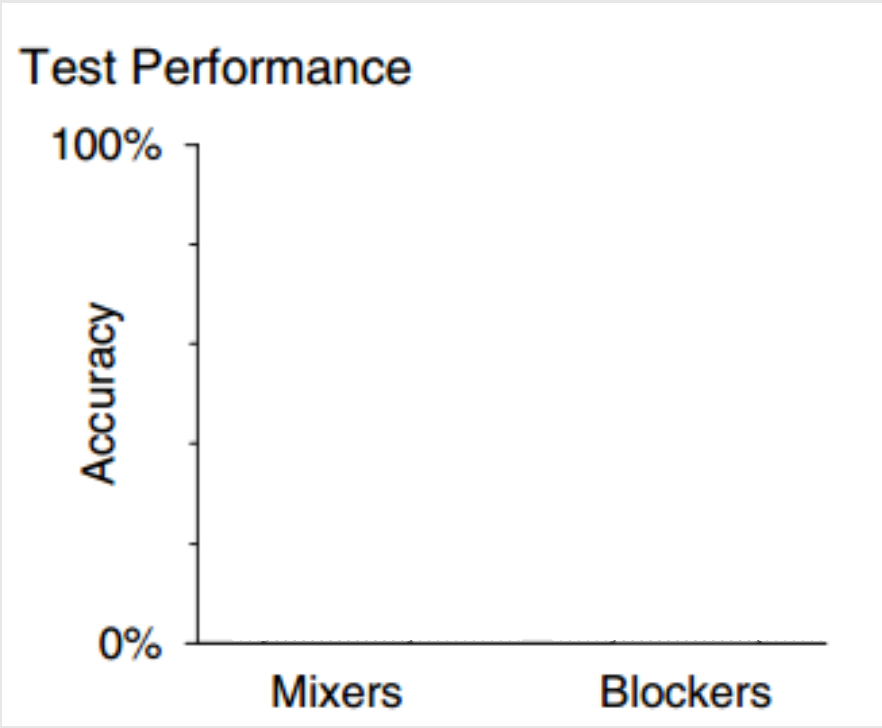
Group	Week 1 (Practice Session 1)	Week 2 (Practice Session 2)	Week 3 Test
Interleaving (mixers)	4 tutorials, interleave problems, visual soln after each problem	4 tutorials, interleave problems, visual soln after each problem	8 novel problems (2 of each solid type) in random order; no feedback
Blockers	Tutorial 1, block 1 of problems; tutorial 2, block 2 of problems; etc. Visual soln after each problem	Tutorial 1, block 1 of problems; tutorial 2, block 2 of problems; etc. Visual soln after each problem	8 novel problems (2 of each solid type) in random order (exact same order as mixers test); no feedback



Interleaving – Mix, Don't Block







Combined practice: blockers > mixers; ($p < 0.01$)

Test: mixers > blockers; $p < 0.05$

Rohrer, D., & Taylor, K. (2007). The shuffling of mathematics problems improves learning. *Instructional Science*, *35*(6), 481-498.

Key Findings

- Mixed practice produced superior test performance and inferior practice performance (compared to blocked practice): $F(1,16)=35.08$, $p < 0.001$
- If students recalled correct formula, the correct answer was almost always found (only one incorrect calculation answer in each a mixer and a blocker).
  - Implies that mixers and blockers knew how to solve each kind of problem at the time of the test
  - Poor performance of blockers was lack of discrimination ability
- Caveats
  - Tasks are procedural; not conceptual
  - Lab-based; not classroom setting

Interleaving of Problem Types

- Mixing together (interleaving) different types of problems during practice slows down initial learning, but leads to better long-term learning and increased ability to differentiate among problem types (Rohrer & Taylor, 2007; Taylor & Rohrer, 2010)
- Practical Implications
  - Difficulty of problems is two-fold: how to solve the problem and what is the problem type (or concept) being asked
  - Interleaving gives practice on both issues

Blocked Homework Schedule

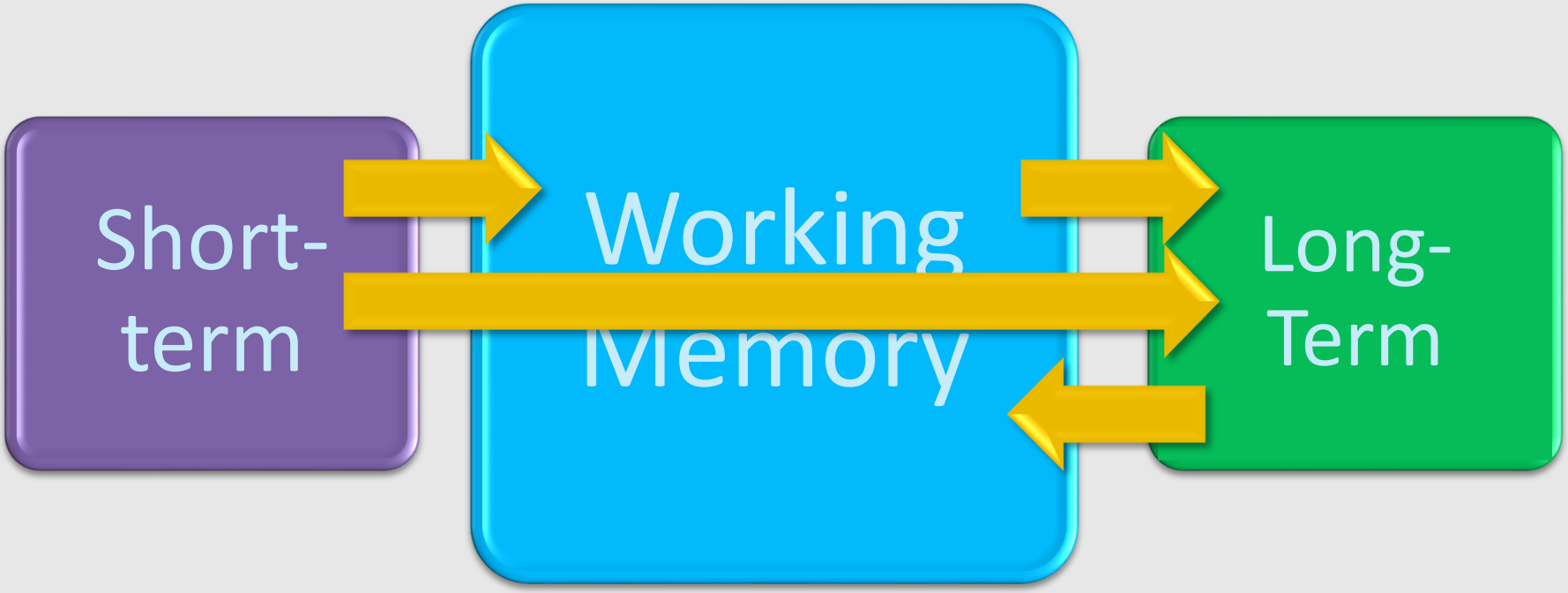
	Week One	Week Two	Week Three	Week Four
Major Lecture Topic	1-Sample t-test	Independent Samples t-test	Paired t-test	1-way ANOVA
Homework Problems	4 Week One	4 Week Two	4 Week Three	4 Week Four

Interleaved Homework Schedule

	Week One	Week Two	Week Three	Week Four
Major Lecture Topic	1-Sample t-test	Independent Samples t-test	Paired t-test	1-way ANOVA
Homework Problems	2 Week One	2 Week Two 1 Week One	2 Week Three 2 Week Two 1 Week One	3 Week Four 1 Week Three 1 Week Two 1 Week One

Note: Problems Types would actually be randomized, not given sequentially as they are listed above

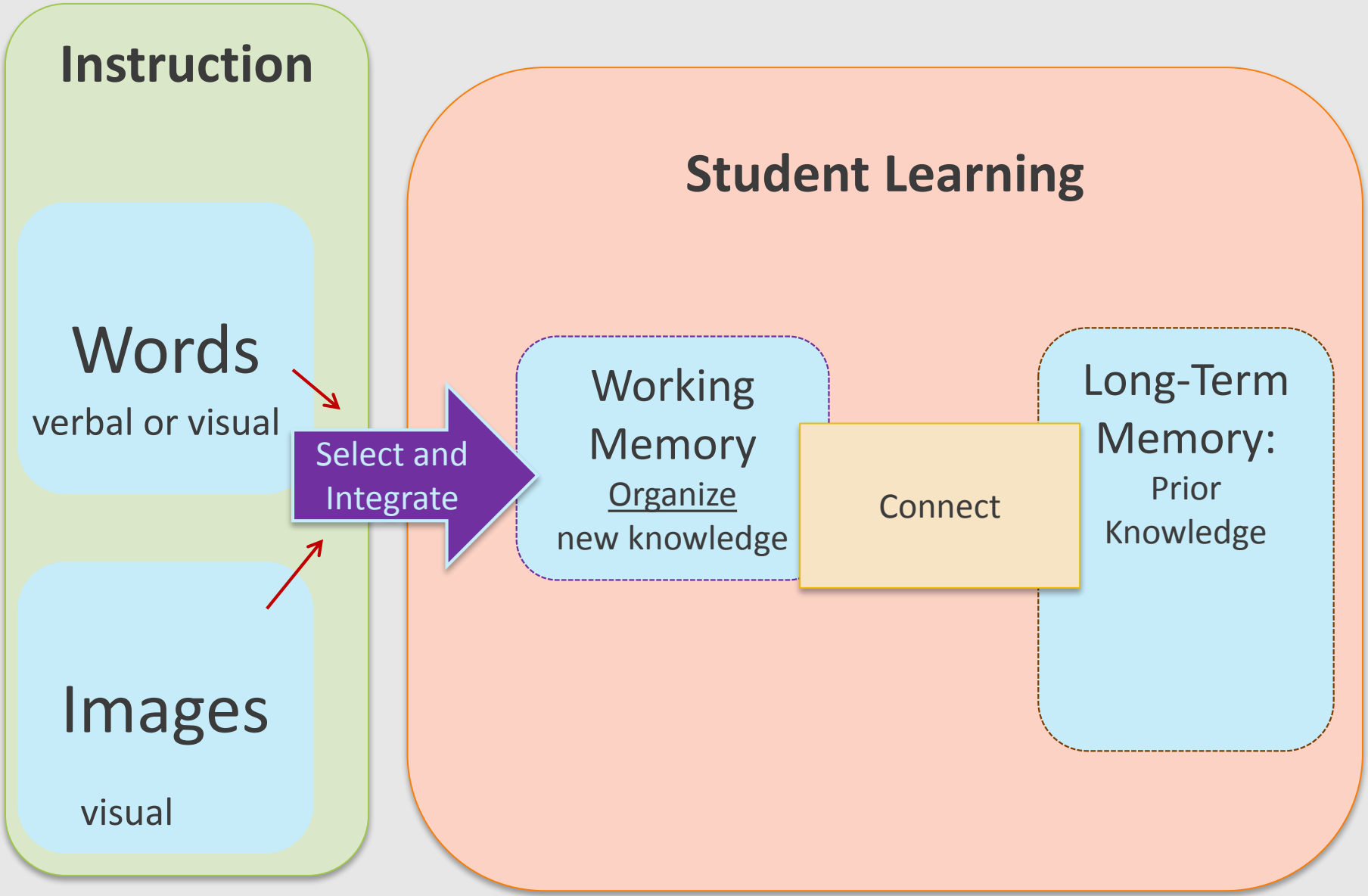
Working Memory



More on Working Memory

Dual Channels for Processing

- Visual versus Verbal Information



Adapted from Mayer, R. E. (Nov. 2008). Applying the Science of Learning: Evidence-Based Principles for the Design of Multimedia Instruction. *American Psychologist*. 760-769.

Combine Visual and Verbal Information, but . . .

Select

Reduce extraneous material

Organize and Connect

Signal most important ideas or facts	Place words and aligned graphics close together	Reduce Redundancy	Help students integrate visual and verbal information	Connect new knowledge to prior knowledge; show relationships

Adapted, from Mayer, R. E. (Nov. 2008). Applying the Science of Learning: Evidence-Based Principles for the Design of Multimedia Instruction. *American Psychologist*. 760-769.

Combining Visual and Verbal Information: An Example

Professor Diana Kleiner, Roman Architecture, Yale University

Discussion

- What does the instructor do to help you learn and remember what she is teaching?

- What could the instructor have done to make it easier for you to learn and remember this information?

Maximizing Working Memory Capacity

Limit the amount of information being presented

Draw on student's prior knowledge

Help students integrate visual and verbal information

Engage students in active processing (e.g. retrieving, making connections)

Attention in the Classroom

Johnstone and Percival (1976)

- Classroom-based study
- Observers recording attention breaks
- Attention lapses start at 10-18 minutes
- Lapses every 3-4 minutes by end of lecture

Johnstone, A. H., & Percival, F. (1976). Attention breaks in lectures. *Education in chemistry*, *13*(2), 49-50.

Attention in the Classroom

Johnstone and Percival (1976) Defined break in attention as:

"…a period of general lack of concentration involving the majority of the class, and not merely isolated individuals"

Attention in the Classroom: Bunce & Flens, 2010

- Method
  - Clickers used to record:
    - Short attention lapse (1 minute or less)
    - Medium attention lapse (2-3 minutes)
    - Long attention lapse (5 minutes or more)
  - Lapses reported after realization they had occurred
  - Lectures, demonstration, and clicker questions studied
  - 6 weeks of data collection

Results

- Attention lapses of 1 minute or less were most common
- At the start of lecture, attention lapses occurred every 3-4 minutes; by the end of lecture – about every 2 minutes
- There were fewer attention lapses reported during and after periods of active learning

Reset and Refresh Attention

Don’t assume that you have your student’s attention for 10-15 minute stretches

Use episodes of active learning to engage and refresh attention

Design class structure for the given session length

Key Concepts

1. Interleaving
2. Designing instruction to maximize learning and retention
3. Reset and refresh attention

Reflective Discussion (5-min)

- Identify one or two concepts or strategies from this discussion that you would like to apply to your teaching.

- What is one concept or area of research that you would like to learn more about?