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

# Study Design

<table>
<thead>
<tr>
<th>Group</th>
<th>Week 1 (Practice Session 1)</th>
<th>Week 2 (Practice Session 2)</th>
<th>Week 3 Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interleaving</td>
<td>4 tutorials, interleave problems, visual soln after each problem</td>
<td>4 tutorials, interleave problems, visual soln after each problem</td>
<td>8 novel problems (2 of each solid type) in random order; no feedback</td>
</tr>
<tr>
<td>(mixers)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blockers</td>
<td>Tutorial 1, block 1 of problems; tutorial 2, block 2 of problems; etc. Visual soln after each problem</td>
<td>Tutorial 1, block 1 of problems; tutorial 2, block 2 of problems; etc. Visual soln after each problem</td>
<td>8 novel problems (2 of each solid type) in random order (exact same order as mixers test); no feedback</td>
</tr>
</tbody>
</table>
Interleaving – Mix, Don’t Block

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

Test: mixers > blockers; p < 0.05

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
1-Sample t-test
4 Week One

Week Two
Independent Samples t-test
4 Week Two

Week Three
Paired t-test
4 Week Three

Week Four
1-way ANOVA
4 Week Four

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Interleaved Homework Schedule

<table>
<thead>
<tr>
<th>Major Lecture Topic</th>
<th>Homework Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Sample t-test</td>
<td>2 Week One</td>
</tr>
<tr>
<td>Independent Samples t-test</td>
<td>2 Week Two 1 Week One</td>
</tr>
<tr>
<td>Paired t-test</td>
<td>2 Week Three 2 Week Two 1 Week One</td>
</tr>
<tr>
<td>1-way ANOVA</td>
<td>3 Week Four 1 Week Three 1 Week Two 1 Week One</td>
</tr>
</tbody>
</table>

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

Short-term to Working Memory to Long-Term
More on Working Memory

Dual Channels for Processing

- Visual versus Verbal Information
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

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

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
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.
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?