Education Grand Rounds: The Science of Learning

Erin Bonura, MD
Assistant Professor
Division of Infectious Diseases
Department of Medicine
Objectives

• Describe the Cognitive Theory of Multimedia
• Compare and contrast “extraneous load” and “germane load” with respect to the Cognitive Load Theory
• Describe how the Primacy-Recency effect applies to your learning sessions
• Identify 3 instructional approaches you can add to your teaching portfolio
fiscal policy & monetary policy effects?
Please type your favorite thing about Portland.

Poll is full and no longer accepting responses.
Please select one of the following that best describes your teaching experience.

- Less than 2 years: 33%
- 2-5 years: 21%
- 5-10 years: 21%
- 10-15 years: 8%
- > 15 years: 17%

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Cognitive Theory of Multimedia

Medical Education 2010: 44: 543–549
Cognitive Theory of Multimedia

- Multimedia presentation
- Sensory memory
  - Words)
  - Ears
  - Sounds
  - Selecting words
  - Organising words
  - Verbal model
  - Integrating
  - Prior knowledge
- Images
  - Eyes
  - Selecting images
  - Organising images
  - Pictorial model
- Working memory
- Long-term memory
  - Web search
  - Ongoing videos, flying animations

Cognitive Load Theory
Would you rather, in a lesson on how rhinovirus infects the human body...

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add "A virus is about 10 x smaller than a bacterium, which is approximately 10 x smaller than a typical human cell. A typical human cell is 10 x smaller than a human hair. Therefore, it can be concluded that a virus is 1,000 x smaller than a hair!"

add "A study conducted by researchers reveals that people who make love once or twice a week are more immune to colds than folks who abstain from sex. Researchers believe that bedroom activity somehow stimulates IgA"
“PASSIVE VS ACTIVE” LEARNING
Think about one of your favorite topics to teach in lecture-style

Use a marker to show over time how much new information is presented over time in a typical class period.
Think about one of your favorite topics to teach in lecture-style.

Use a marker to show over time how much new information is presented over time in a typical class period.

New Content and Levels of Retention

• Highest level of information retained in the first 5 to 12 minutes of class
• Low levels of retention for new content during middle of class
• Increase in retention in the last five minutes of class

The Learning Pyramid

Average Retention Rates

- 5% Lecture
- 10% Reading
- 20% Audio-Visual
- 30% Demonstration
- 50% Group Discussion
- 75% Practice
- 90% Teaching Others

Adapted from National Training Laboratories. Bethel, Maine
Would you rather, in a lesson on how rhinovirus infects the human body...

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Add: "A virus is about 10 x smaller than a bacterium, which is approximately 10 x smaller than a typical human cell. A typical human cell is 10 x smaller than a human hair. Therefore, it can be concluded that a virus is 1,000 x smaller than a hair!"

Add: "A study conducted by researchers reveals that people who make love once or twice a week are more immune to colds than folks who abstain from sex. Researchers believe that bedroom activity somehow stimulates IgA"
Interestingness of Extraneous Material

• Not all extraneous information is interesting
• *Seductive detail* is material that is interesting but not essential for the instructional goal
• Adding seductive detail is extraneous
• Is there a difference in student performance depending on the “interestingness” of extraneous material?

Interestingness of Extraneous Material

- 89 college students, 2 experiments
- 3 multimedia groups: booklet, PPT, animation
- High and low interest interventions
- Retention and transfer tests

Viral Cell Entry-Exit

STEP 1: Entering the body.

STEP 2: Attaching to a host cell.

STEP 3: Injecting genetic material into the host cell.

STEP 4: Copying the virus' genetic code.

STEP 5: Breaking free from the host cell.

STEP 6: Spreading throughout the body.
High Interestingness Decreases Deeper Processing

<table>
<thead>
<tr>
<th>Test measure and presentation medium</th>
<th>Level of interest of extraneous details</th>
<th>Low</th>
<th>High</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Transfer score</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Booklet</td>
<td>5.0</td>
<td>2.2</td>
<td>4.1</td>
<td>2.1</td>
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<tr>
<td>PowerPoint</td>
<td>7.3</td>
<td>2.6</td>
<td>4.9</td>
<td>2.0</td>
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<tr>
<td>Narrated animation</td>
<td>5.4</td>
<td>2.4</td>
<td>3.3</td>
<td>1.4</td>
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<tr>
<td>Total</td>
<td>5.9a</td>
<td>2.4</td>
<td>4.1</td>
<td>1.9</td>
</tr>
<tr>
<td>Retention score</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Booklet</td>
<td>6.5</td>
<td>2.2</td>
<td>6.1</td>
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<td>4.9</td>
<td>1.2</td>
<td>4.9</td>
<td>1.1</td>
</tr>
<tr>
<td>Total</td>
<td>5.9</td>
<td>2.4</td>
<td>5.8</td>
<td>1.8</td>
</tr>
</tbody>
</table>
Would you rather assign the following epidemiology prework on a qualitative concept (i.e. pandemics):

- A concise reading on 6 pages containing 653 words and 6 illustrations: 72%
- An expanded reading identical to the concise reading with added 327 words and 5 illustrations focusing on equations, symbols and computations: 28%

When poll is active, respond at [PollEv.com/erinbonura278](http://PollEv.com/erinbonura278)

Text [ERINBONURA278](#) to [22333](#) once to join
Less is more

- Adding extraneous words, pictures, video clips and narration, sounds create a heavy cognitive load (d=0.71-1.68)
- Addition of quantitative details had not been studied
- Mayer conducted a study using ocean waves
- Extraneous material added = formulas, quantitative graphs
- Post-test scores concise vs expanded:
  - mean 7.46 vs 5.28
- Effect size = 0.97

Would you rather have your students watch a video like...

Poll is full and no longer accepting responses

52%

48%
Less is More – Dual Channel Theory

• 5 of 5 experiments, better without text
• Median effect size 0.72

Would you rather present your material as the slide on the LEFT or RIGHT? Please touch the slide you would create.

When poll is active, respond at PollEv.com/erinbonura278

Treatment of Hypovolemic Shock

- Fluid replacement

1. Crystalloids: Hypo, Hyper, Iso Osmotic (NaCl, D5W, LR) → Interstitium
2. Colloids: Synthetic (Starch), Natural (blood products, Albumin) → Intravascular
3. Blood and blood products

Interstitial  Intravascular
Multimedia Design and Improved Retention

• Issa et al, designed study asking if adhering to multimedia design increases retention
• 80 Third-year medical students
• Traditional PPT group vs redesign group according to Mayer’s principles
  – Heading of slide state the main assertion
  – Eliminate distractors
  – Visual representations
  – Reduce word count
  – End with a conclusion slide

Medical Education 2013: 47: 388–396
## Results

<table>
<thead>
<tr>
<th></th>
<th>Pre-test Mean, SD</th>
<th>Immediate PT Mean, SD</th>
<th>1 Week Mean, SD</th>
<th>4 Week Mean, SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transfer</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modified</td>
<td>1.99 ± 1.18</td>
<td>3.71 ± 1.13</td>
<td>3.51 ± 1.16</td>
<td>3.71 ± 0.93</td>
</tr>
<tr>
<td>Traditional</td>
<td>2.21 ± 1.05</td>
<td>2.94 ± 0.83</td>
<td>2.61 ± 0.99</td>
<td>2.52 ± 1.12</td>
</tr>
<tr>
<td>T-test</td>
<td>0.4142</td>
<td>0.0020</td>
<td>0.0006</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td><strong>Retention</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modified</td>
<td>2.41 ± 0.65</td>
<td>4.41 ± 0.47</td>
<td>3.69 ± 0.77</td>
<td>3.51 ± 0.81</td>
</tr>
<tr>
<td>Traditional</td>
<td>2.27 ± 0.62</td>
<td>3.73 ± 0.44</td>
<td>3.13 ± 0.53</td>
<td>2.95 ± 0.54</td>
</tr>
<tr>
<td>T-test</td>
<td>0.4156</td>
<td>&lt; 0.0001</td>
<td>0.0010</td>
<td>0.0009</td>
</tr>
</tbody>
</table>
Dip Our Toes into Active Learning

- Rate these from low, moderate, high
- Faculty and students can do these

<table>
<thead>
<tr>
<th>Method</th>
<th>Utility (Low, Moderate, High)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highlighting</td>
<td></td>
</tr>
<tr>
<td>Summarizing</td>
<td></td>
</tr>
<tr>
<td>Practice Testing</td>
<td></td>
</tr>
<tr>
<td>Spaced Practice</td>
<td></td>
</tr>
<tr>
<td>Elaborative Interrogation</td>
<td></td>
</tr>
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</table>

What Works, What Doesn’t

## What Learning Strategies Work?

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<tr>
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<th>Utility (Low, Moderate, High)</th>
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<tbody>
<tr>
<td>Highlighting</td>
<td>Low</td>
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<td>Low</td>
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<tr>
<td>Practice Testing</td>
<td>High</td>
</tr>
<tr>
<td>Spaced Practice</td>
<td>High</td>
</tr>
<tr>
<td>Elaborative Interrogation</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

Highlighting – Low Utility

- Commonly used among students (active highlighting)
- Some faculty highlight for students (passive highlighting)
- Benefits:
  - Better retention on selected content
  - Active > passive highlighting
- Costs:
  - Students did not do well with probing questions
- Overall
  - Most studies show little to no benefit of highlighting over reading
  - Effective highlighters may benefit some but cost comes in ability to draw inferences and transfer content

Summarizing – Low Utility

• Summarizing involves extracting higher level meaning
• Summarizing performed better than verbatim copying
• Benefits: can lead to better integration
• Costs: need to learn how to summarize
• Overall: Likely better than re-reading and highlighting for trained summarizers but need more classroom studies

Elaborative interrogation – Moderate Why??

• Generate an explanation for a stated fact
• Invites discrimination of related entities (compare and contrast)
• Benefits: increase recall of factual information, minimal training needed
• Costs: few studies show improvement in comprehension or application or use of long term retention
• Overall: High knowledge learners may benefit the most, complex material remains a concern, need more generalizability studies

Practice Testing – High Utility

- 100 years of research shows that practice testing enhances learning and retention
- Benefits both high and low achieving learners
- Learners do not like it
- Most experience high stakes, summative assessments

Spaced Practice – High Utility

• Many learners prefer to “cram”
• Distributed learning benefits long-term memory
• Classic experiment by Bahrick et al. c 1979

Spaced Practice – High Utility

• Timing of the lag depends on how long the learner needs to retain the information
• Benefits: effects are robust
• Costs: some training involved, buy in of the learner is needed
• Overall: Little effort to implement and high payoff with long-term retention.

Summary

• Consider cognitive load when designing learning sessions
• Small changes in multimedia design can enhance learner retention and translation
• Though learners prefer highlighting and “cramming”, practice testing and spaced learning lead to better outcomes
<table>
<thead>
<tr>
<th>Mayer’s principles for designing effective instructional multimedia materials</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Eliminate external distracters</strong></td>
</tr>
<tr>
<td>Coherence principle</td>
</tr>
<tr>
<td>Signalling principle</td>
</tr>
<tr>
<td>Redundancy principle</td>
</tr>
<tr>
<td>Spatial contiguity</td>
</tr>
<tr>
<td>Temporal contiguity</td>
</tr>
<tr>
<td><strong>Encourage learners to establish ‘mental frames’ for the material</strong></td>
</tr>
<tr>
<td>Segmenting principle</td>
</tr>
<tr>
<td>Modality principle</td>
</tr>
<tr>
<td>Pre-training principle</td>
</tr>
<tr>
<td><strong>Facilitate integration of new material with prior established knowledge</strong></td>
</tr>
<tr>
<td>Multimedia principle</td>
</tr>
<tr>
<td>Personalisation principle</td>
</tr>
<tr>
<td><strong>Exclude extraneous words, pictures and sounds</strong></td>
</tr>
<tr>
<td>Highlight essential material</td>
</tr>
<tr>
<td>Do not add on-screen text to narrated animation</td>
</tr>
<tr>
<td>Place printed words next to corresponding graphs</td>
</tr>
<tr>
<td>Place corresponding narration and animation at the same time</td>
</tr>
<tr>
<td><strong>Present animation in learner-paced segments</strong></td>
</tr>
<tr>
<td>Present words as narration instead of printed text</td>
</tr>
<tr>
<td>Prepare/read ahead of time</td>
</tr>
<tr>
<td><strong>Present words and pictures rather than words alone</strong></td>
</tr>
<tr>
<td>Employ conversational style instead of formal dry style to present words</td>
</tr>
</tbody>
</table>

Adapted from Mayer\textsuperscript{22}