Learning in a Digital World

Plenary Session

“Applications of Psychological Science to Learning Using Technology”

Victor A. Benassi
Applications of Psychological Science to Learning Using Technology

http://www.unh.edu/teaching-excellence/resources/Multimedia%20learning.html

Victor A. Benassi
Professor of Psychology
Faculty Director, Center for Excellence in Teaching and Learning
vab@unh.edu

Acknowledgments

• This work is made possible by a grant from the Davis Educational Foundation. The Foundation was established by Stanton and Elisabeth Davis after Mr. Davis's retirement as chairman of Shaw's Supermarkets, Inc.

• This work is also supported by the University of New Hampshire (UNH) Office of the Provost and Vice President for Academic Affairs.

• Special thanks to Catherine Overson for developing and designing the UNH-based research described in the presentation and to Elizabeth Tappin for her work on the assessment components of the projects. Thanks also to Lou Ann Griswold, Adam St. Jean, Michael Melville, Barbara White, Rosemary Caron, Charlie Putnam, and Trish Cox, teachers of and collaborators on the projects described in this presentation.
BDA

Before the Digital Age

(Circa 1954 – 1975)
B.F. Skinner’s Teaching Machines
B.F. Skinner’s Teaching Machines

https://www.youtube.com/watch?v=jTH3ob1IRFo
Educational Public Television: “Watch Mr. Wizard”

http://www.youtube.com/watch?v=Zlavyfr6llzs
https://www.youtube.com/watch?v=rf5_iwobNb4
In the Digital Age
Computer Games:
Do they facilitate student learning?
Video: More and fancier video production does not necessarily facilitate learning

Firing Neurons | Cell Dance 2010, Public Outreach Video Winner
http://www.biotechniques.com/multimedia/videos/?pager.offset=48
Leonard Bosgraaf, Ph.D., Molecular Shots, Inc, of Groningen, The Netherlands, for "Firing Neurons," a movie created entirely by computer animation

What YouTube viewers say:

“Incredible Science Animation About Neurons!”
“What is name of the music please?”
“This video helped me in understanding how neurons communicate. Please make more. Very informative. Thank you.”

Followed by:
“Wow, no f------g kidding!”
45% of the video with violins, but no words.

Only images of neurons that do not inform.
http://www.youtube.com/watch?v=haNoq8UbSyc
Contrast the previous with this. Not so cool, but effective?

http://www.youtube.com/watch?v=d648WiEchtQ
Carnegie Mellon University Open Learning Initiative
e-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning
Intelligent Tutoring Systems

Auto-Tutor (PI: Arthur Graesser, University of Memphis)

“AutoTutor is a computer tutor that helps students learn by holding a conversation in natural language. AutoTutor tracks the cognition and emotions of the student and responds in a manner that adapts to the student. AutoTutor has been developed to help students learn about physics and computer literacy. Emotions are recognized by the dialogue patterns, facial expressions, and body posture of the student.”

http://www.memphis.edu/iis/projects/autotutor/
Cognitive Tutors

Another type of Intelligent tutor.

Development based on John Anderson's ACT-R theory.

The Power of Learning Analytics

Yesterday, Linda Baer called learning analytics “The Game Changer.”

Remainder of this presentation will focus on how my colleagues and I have used data to assess the impact of instructional interventions and to make course adjustments, based on principles of psychological science.
Overview of Remainder of Presentation

1. **Using Personal Response Systems** (iClicker) in the Classroom to Promote Student Learning in a Lower-Division Course on Energy and Environment.

2. **Embedding Questions** in Online Video Lectures in a Graduate-Level “Flipped” Course on Occupational Therapy for Children.

3. **Applying Multimedia Principles** with Face-To-Face and Online PowerPoint Presentations.
Using Personal Response Systems

Using Personal Response Systems (iClicker) in the Classroom to Promote Student Learning in a Lower-Division Course on Energy and Environment.

Course: Energy and Environment

Enrollment: > 200

Question: Does “clicking” make a difference?
Partial Assessment of a Peer Instruction Method

http://mazur.harvard.edu/research/detailspage.php?ed=1&rowid=8

- Presentation of in-class questions – three clicker conditions
- Teacher presented some material followed by a question using a particular presentation strategy.
- Repeated 3 times per class period.
- On different class days, teacher either:
  1. Click/peer-to-peer discussion/click
  2. Click/think/click
  3. Think/peer-to-peer discussion/think
- After each condition, teacher provided correct response
An In-Class Question

If you were asked to convert 12 $\text{in}^2$ into $\text{m}^2$, which conversion factor would be the correct one to use?

A \[ \frac{1 \text{ in}}{0.0254 \text{ m}} \]

B \[ \frac{0.0254 \text{ m}}{1 \text{ in}} \]

C \[ \left( \frac{1 \text{ in}}{0.0254 \text{ m}} \right)^2 \]

D \[ \left( \frac{0.0254 \text{ m}}{1 \text{ in}} \right)^2 \]
During the solution of a problem you decide to use the unit conversion factor \( \frac{1 \text{ yr}}{8,760 \text{ hr}} \). What conversion are you most likely trying to accomplish?

A. hours to years  
B. years to hours  
C. years to days  
D. days to years
Inserting Embedded Questions into Lecture-Capture Presentations May Promote Learning and Long-Term Retention
Embedding Questions in Online Video Lectures in a Graduate-Level “Flipped” Course on Occupational Therapy for Children

• Master’s Level Course: Occupational Therapy for Children
• Flipped Class
• Enrollment = 60+
Project Intervention

• Generation of specific objectives (advance organizers)
• Presentation of base materials (Pre-training)
• Embedded questions in pre-training presentations
• Questions were either:
  1. Multiple-choice (quiz condition)
  2. Summary Statement (study control)
  3. Not-asked (not-asked control)
Mean proportion correct on midterm exam questions for each of the three experimental conditions.
Multimedia Learning
Multimedia Design
Two Approaches

## Our Approach

<table>
<thead>
<tr>
<th>Science of Learning</th>
<th>Science of Instruction</th>
<th>Science of Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Load Theory</td>
<td>Multimedia principles of instruction</td>
<td>Use of authentic measures of student performance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Learning</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Retention</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Transfer</td>
</tr>
</tbody>
</table>

Cognitive Load

**Extraneous Cognitive Load**
- ✓ Does not serve the instructional goal
- ✓ Poor instructional design

**Essential Cognitive Load**
- ✓ Represents essential material in working memory
- ✓ Load depends on Complexity of material

**Generative Cognitive Processing**
- ✓ Required for deep understanding of material (e.g., construction of schemas)
- ✓ Good instructional design—increases student motivation to learn
Goals of Multimedia Instruction

Minimize Extraneous Load

Manage Essential Load

Foster Generative Processing
## Minimize Extraneous Load

Table 2, Mayer, 2014 (page 62)

<table>
<thead>
<tr>
<th>Principle</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coherence</td>
<td>Delete extraneous material</td>
</tr>
<tr>
<td>Signaling</td>
<td>Highlight essential material</td>
</tr>
<tr>
<td>Redundancy</td>
<td>Don’t add onscreen captions to narrated graphics</td>
</tr>
<tr>
<td>Spatial contiguity</td>
<td>Place printed words near corresponding part of graphic</td>
</tr>
<tr>
<td>Temporal contiguity</td>
<td>Present spoken words at same time as corresponding graphics</td>
</tr>
</tbody>
</table>
## Manage Essential Load

Table 3, Mayer, 2014 (page 64)

<table>
<thead>
<tr>
<th>Principle</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Segmenting</td>
<td>Break lesson into learner-paced parts</td>
</tr>
<tr>
<td>Pre-training</td>
<td>Present characteristics of key concepts before lesson</td>
</tr>
<tr>
<td>Modality</td>
<td>Use spoken words rather than printed words</td>
</tr>
</tbody>
</table>
# Foster Generative Processing

Table 4, Mayer, 2014 (page 66)

<table>
<thead>
<tr>
<th>Principle</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personalization</td>
<td>Put words into conversational style rather than formal style</td>
</tr>
<tr>
<td>Voice</td>
<td>Put words into human voice rather than machine voice</td>
</tr>
<tr>
<td>Embodiment</td>
<td>Have onscreen agent use human-like gestures and movements</td>
</tr>
<tr>
<td>Image</td>
<td>Do not necessarily put an image of agent on the screen</td>
</tr>
</tbody>
</table>
Multimedia Projects

1. In-Class *PowerPoint* Projects
   - Mixture of multimedia principles
2. Out of class *PowerPoint* Projects
In-class PowerPoint projects

Experimental Design
Multimedia Principle

“People learn better from words and pictures than from words alone.”

Mayer, page 223
Descriptive vs. Analytic Epidemiology

- **Descriptive studies**--used to identify a health problem that may exist. Characterize the amount and distribution of disease.
- **Analytic studies**--follow descriptive studies, and are used to identify the cause of the health problem.
<table>
<thead>
<tr>
<th>Descriptive Studies</th>
<th>Analytic Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Used to identify a health problem that may exist. Characterize the amount and distribution of disease.</td>
<td>Follow descriptive studies, and are used to identify the cause of the health problem.</td>
</tr>
</tbody>
</table>
Signaling Principle

“People learn better when cues that highlight the organization of the essential material are added”

Mayer, page 108
Example 1

ORIGINAL
Cardiovascular Disease and Chronic Stress Pathway

1. Increased stress produces stress hormones that pump the heart more and increase wear and tear.

2. Blood pressure increases to pump blood faster during the stress response.

3. Increased blood pressure forces the body to produce stronger vessels to handle the pressure, leading to increased pressure.

4. The heart thickens to handle the increased pressure.

5. Increased pressure causes damage to blood vessels.

6. Blood that is sort of sticky and filled with cholesterol, fats, glucose.
   - This can happen anywhere but when it happens to actual heart vessels a person is at even greater risk.
Cardiovascular Disease and Chronic Stress Pathway

1. Increased stress produces **stress hormones** that pump the heart more and increase wear and tear.

2. **Blood pressure** increases to pump blood faster during the stress response.

3. Increased blood pressure forces the body to produce **stronger vessels** to handle the pressure, leading to increased pressure.

4. The heart thickens to handle the increased pressure.

5. Increased pressure causes **damage to blood vessels**.

6. **Blood that is sticky** (i.e., filled with cholesterol, fats, glucose due to chronic stress response) gets trapped in damaged vessels.
Coherence Principle

“People learn better when extraneous material is excluded rather than included”

Mayer, page 89
Positivist Approach
Positivist Approach

- Donald Black: perspective & method of natural sciences
  - Form & test hypotheses empirically
Positivist Approach

• Donald Black: perspective & method of natural sciences
  – Form & test hypotheses empirically

• Some hypotheses:
Positivist Approach

• Some hypotheses:
  - Law varies inversely w/ other social control
  - > stratification = more law
  - > “downward law” than “upward law”
  - > law as intimacy decreases [most law where people interact a lot w/ little intimacy]
Law varies inversely w/ other social control
- > stratification = more law
- > “downward law” than “upward law”
- > law as intimacy decreases [most law where people interact a lot w/ little intimacy]
Positivist Approach

– > stratification = more law
– > “downward law” than “upward law”
– > law as intimacy decreases [most law where people interact a lot w/ little intimacy]
Positivist Approach

– "downward law" than "upward law"

– law as intimacy decreases [most law where people interact a lot w/ little intimacy]
Positivist Approach

- > law as intimacy decreases [most law where people interact a lot w/ little intimacy]
Positivist Approach
Positivist Approach

- Donald Black: perspective & method of natural *sciences*
  - Form & test hypotheses empirically

- Some hypotheses:
  1. Law varies inversely with other social control
  2. > stratification = more law
  3. > “downward law” than “upward law”
  4. > law as intimacy decreases
    - most law where people interact a lot with little intimacy
Learning Outcomes
Experiment 1:

Learning

Mean Percent Correct Responses to Questions Asked at End of Class During Which Modified or Original PowerPoint Slides Were Presented.
Mean Percent Correct Responses to **Questions Asked at End of Class** During Which Modified or Original PowerPoint Slides Were Presented.
Mean Percent Correct Responses to Questions Asked at End of Class During Which Modified or Original PowerPoint Slides Were Presented.
Experiment 2:
Long-Term Retention
Mean Percent Correct Responses to
Midterm Exam Questions Based on
Information in Modified or Original
PowerPoint Slides
Mean Percent Correct Responses to **Midterm Exam Questions**
Based on Information in Modified or Original PowerPoint Slides.
Mean Percent Correct Responses to **Midterm Exam Questions** Based on Information in Modified or Original PowerPoint Slides.

![Bar chart showing mean percent correct responses to midterm exam questions based on information in modified or original PowerPoint slides. The x-axis represents three categories: Original, Modified, and Diff (difference). The y-axis represents the mean percent correct responses, ranging from -20 to 100. The chart indicates that the Modified category has a higher mean percent correct responses compared to the Original category. The Diff category shows the difference between the Modified and Original categories.](image-url)
Out-of-class PowerPoint projects
Introduction to Psychology Course

Experiment Design
Attitudes
(Word Version)
Attitude Change by Our Own Behavior

• We hold many cognitions (for example: beliefs, feelings, and our behavior) about ourselves and the world around us

• We expect our cognitions to be in harmony with one another – that is, we expect that our attitudes and our behaviors are consistent/compatible

• Sometimes we behave in ways that are inconsistent with our attitudes. These conflicting cognitions produce an unpleasant psychological state – cognitive dissonance – that we strive to reduce

• Because we cannot change our past behavior, one way to reduce the dissonance is by changing our attitudes so that they are more in line with our behavior
Attitudes
(Multimedia Version)
Attitude Change by Our Own Behavior
Attitude Change by Our Own Behavior

We hold many cognitions about ourselves and the world around us, which we expect to be consistent/compatible with one another.
Attitude Change by Our Own Behavior

We hold many cognitions about ourselves and the world around us, which we expect to be consistent/compatible with one another.
Attitude Change by Our Own Behavior
Attitude Change by Our Own Behavior

When we behave in ways that are inconsistent with our attitudes, we experience an unpleasant psychological state that we strive to reduce.
Attitude Change by Our Own Behavior

When we behave in ways that are inconsistent with our attitudes, we experience an unpleasant psychological state that we strive to reduce.
Attitude Change by Our Own Behavior

When we behave in ways that are inconsistent with our attitudes, we experience an unpleasant psychological state that we strive to reduce.

Beliefs  
Feelings  
Behavior  
Cognitive dissonance
Attitude Change by Our Own Behavior
Attitude Change by Our Own Behavior

Because we cannot change past behavior, we reduce dissonance by changing our attitudes to align with our behavior.
Attitude Change by Our Own Behavior

Because we cannot change past behavior, we reduce dissonance by changing our attitudes to align with our behavior.
Attitude Change by Our Own Behavior

Because we cannot change past behavior, we reduce dissonance by changing our attitudes to align with our behavior.
Attitude Change by Our Own Behavior

Because we cannot change past behavior, we reduce dissonance by changing our attitudes to align with our behavior.
Attitude Change by Our Own Behavior

Because we cannot change past behavior, we reduce dissonance by changing our attitudes to align with our behavior.

- Attitude
- Discrepant Behavior
- Cognitive Dissonance
  - Strive for Dissonance Reduction
Attitude Change by Our Own Behavior

Because we cannot change past behavior, we reduce dissonance by changing our attitudes to align with our behavior.
Attitude Change by Our Own Behavior

Because we cannot change past behavior, we reduce dissonance by changing our attitudes to align with our behavior.

- Attitude
- Discrepant Behavior
- Cognitive Dissonance
- Strive for Dissonance Reduction
- Attitude change
Learning Outcomes
Quiz Performances Following Multimedia and Word Formats: Learning
The Neuron
The Action Potential
Classical Conditioning
Operant Conditioning
Attribution

MM

Word

Diff
Difference between mean test scores of Multimedia and Word versions of presentations. (Positive values indicate between performance on questions from multimedia presentations.)

<table>
<thead>
<tr>
<th>Instructional Topics</th>
<th>Percent Difference Between Test Scores From Multimedia and Word Presentation Formats</th>
</tr>
</thead>
<tbody>
<tr>
<td>neuron</td>
<td>5</td>
</tr>
<tr>
<td>action potential</td>
<td>4</td>
</tr>
<tr>
<td>classical conditioning</td>
<td>6</td>
</tr>
<tr>
<td>Operant conditioning</td>
<td>8</td>
</tr>
<tr>
<td>attitudes</td>
<td>6</td>
</tr>
<tr>
<td>attribution</td>
<td>5</td>
</tr>
</tbody>
</table>
Wrap Up

Three sets of studies demonstrate that authentic academic performance is positively affected by conditions of instruction:

1. Providing opportunities for deep processing *during lectures* facilitates learning, with or without clickers.

2. *Embedding* questions during online lectures produces a kind of “testing effect.”

3. *Developing* PowerPoint slides that use multimedia instructional methods (science of instruction) can positively affect both initial learning and long-term retention of material presented during in-class lectures.

We use data from studies used to inform improvements in instruction and to develop “promising practices.”