Flipping the Script: Innovating Large Undergraduate Lectures with Principles from Cognitive Science

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Problem

• Large lecture (n > 100) affords direct instruction w/ limited discussion

• Less effective than other learning activities (Chi, 2009; Chi & Wiley, 2015)

• Challenge to keep students actively engaged and motivated (Leicht et al., 2013; Hake, 1998; Strayer, 2013)
Solution and Challenge

• **Solution:** Principles of cognitive science
  (Branford, Brown, & Cocking, 2000; Dunlosky et al., 2013)
  - Self-explanation, analogical comparison, and retrieval-practice

• **Challenge**
  
  • How to implement and integrate these principles into instruction for a large lecture course?
    - flipping class content and activity (e.g., Leicht et al., 2012)

  • Opportunity: Relatively little is known about how these principles impact student motivation (interest, goals, beliefs)
    (Belenky & Nokes-Malach, 2012; Zepeda et al., 2015)
Self-Explanation

- Explanation of worked examples or expository text (Chiu & Chi, 2014; Fonseca & Chi, 2011)

- Why?
  - Generating inferences from prior knowledge (Chi, 2000)
  - Helps to repair mental models (Chi, 2000)
  - Explanation helps identify sub-goals (Catrambone, 1996)
  - Laboratory evidence across a number of domains: physics, biology, mathematics, electronics

House
Isa: building
Parts: rooms and windows
Materials: wood, brick, stone
Function: human dwelling
Shape: rectilinear, triangular
Size: 100-10,000 sq ft.
Analogies can facilitate learning and problem solving (Gentner, Holyoak, & Kokinov, 2001).

Why?

- Facilitates abstraction, acquisition of a problem schema, and a focus on the underlying concept (e.g., Gick & Holyoak, 1983; Nokes-Malach et al., 2013).

What is similar across the problems?

**House**
- Isa: building
- Parts: rooms and windows
- Materials: wood, brick, stone
- Function: human dwelling
- Shape: rectilinear, triangular
- Size: 100-10,000 sq ft.

**John’s house** is a building where he lives that consists of 10 rooms and 20 windows. It is made of wood and brick. It is a large rectangle and is approximately 9,000 sq. feet.

**Sarah’s House** is a building where she and her family lives that consists of 5 rooms and 9 windows. It is made of brick and stone. It is a large rectangle and is approximately 3,450 sq. feet.
Retrieval practice

• Testing that is completed as a formative assessment

• Many studies have shown that it improves learning and retention compared to restudy (Karpicke & Roediger, 2006)

• Why?
  • Direct effects: generative versus passive; elaborative retrieval processes (activates related info); organization of retrieval
  • Indirect effects: figure out what one does not know, opportunity for future study
Class

• 422 Cognitive Psychology
  Science of the mind: perception, attention, memory, language, concepts, problem solving, expertise, creativity, etc.

• One of five psychology core courses

• 200 students
  • About even split between sophomore, junior, and senior
  • ~ 65/35 split between Major and Non-majors
Pre-lecture quiz and video

- 8 pre-lecture quizzes and videos

Part 1: review
(3-6 questions)

Feedback on part 1
Performance

Option to retake incorrect
Review questions

In visual perception, top-down processing is:

A. Influenced by prior knowledge and driven by expectations
B. Influenced by the environment and driven sensory information
C. Out of one’s control
D. B and C only
Pre-lecture quiz and video

- 8 pre-lecture quizzes and videos
Pre-lecture quiz and video

- 8 pre-lecture quizzes and videos

Part 3: Pre-Lecture Video Quiz

Feedback on Pre-Lecture Quiz Performance

Option to re-watch the Pre-Lecture Video

Option to retake incorrect Pre-Lecture Quiz questions

University of Pittsburgh

Please answer the following questions about the video you just watched.

Focused attention is the:

A. Ability to attend to or select some information and ignore other information
B. Ability to perform multiple tasks simultaneously
C. Ability to perform tasks automatically
D. Ability to predict where to look for information
End-of-lecture quiz

1. What does the Sperling (partial report) Experiment tell us about sensory stores and when we select information?
   A. We encode a lot of information initially and are able to remember all of it for long periods of time.
   B. Only a very small amount of information is available initially, and we can remember it for a long time.
   C. We encode a lot of information initially, but if it is not selected then it is lost.
   D. The longer the delay between encoding and recall the more we can remember.

2. What type of information does our attentional system select?
   A. Spatial
   B. Object
   C. Both
   D. Neither

3. Cherry’s (1953) dichotic listening experiment was significant as it provided initial evidence for which theory?
   A. Early selection
   B. Late selection
   C. Attenuation theory
   D. Object based selection

4. Briefly describe the attenuation model. How does it work?
Assessment

• Motivation and Engagement
  - **Surveys**: interest, value, achievement goals, self-efficacy, theory of intelligence, and grit
  - Participation

• Learning
  - Surveys: study skills (cognitive and meta-cognitive)
  - 3 Exams (35 multiple choice question)
  - Design Challenges
Preliminary results

Comparison

Fall-Comparison  Spring-Flipped

++ 4
+

Pretest  Posttest  Pretest  Posttest

Fascination  Value
## Preliminary results

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<th>Fall-Comparison</th>
<th>Spring-Flipped</th>
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<td>Performance-Approach</td>
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### Fall-Comparison
- Pretest Mastery-Approach: ++
- Pretest Performance-Approach: +
- Pretest Performance-Avoidance: -
- Posttest Mastery-Approach: ++
- Posttest Performance-Approach: +
- Posttest Performance-Avoidance: -

### Spring-Flipped
- Pretest Mastery-Approach: ++
- Pretest Performance-Approach: +
- Pretest Performance-Avoidance: -
- Posttest Mastery-Approach: ++
- Posttest Performance-Approach: +
- Posttest Performance-Avoidance: -
Preliminary results

- Fall-Comparison
- Spring-Flipped

Pretest | Posttest | Pretest | Posttest | Pretest | Posttest
---------|----------|---------|----------|---------|----------
Self-efficacy | Theory of Intelligence | Grit

+++ 6
++ 5
+ 4
- 3
--- 2
--- 1
Motivation Summary

- Decreases in fascination and value pre to post; No differences across classes
- Decreases in mastery and performance goals pre to post. Comparison class reported overall higher endorsement of performance goals
- No differences in self-efficacy; Flipped class more strongly endorsed a malleable theory of intelligence and higher grit
- *Were between class differences driven by course structure and expectations or individual differences coming into the class?*
Assessment

• Motivation and Engagement
  - Surveys: interest, value, achievement goals, self-efficacy, theory of intelligence, and grit
  - Participation

• Learning
  - **Surveys:** study skills (cognitive and meta-cognitive)
  - 3 Exams (35 multiple choice question)
  - Design Challenges
Assessment

- Motivation and Engagement
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<td>Exam 3</td>
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Percent Correct

- Exam 1: Fall-Comparison and Spring-Flipped
- Exam 2: Fall-Comparison and Spring-Flipped
- Exam 3: Fall-Comparison and Spring-Flipped

Comparison:
- $d = 0.13$
- $d = 0.27$
Assessment

• Motivation and Engagement
  - Surveys: interest, value, achievement goals, self-efficacy, theory of intelligence, and grit
  - Participation

• Learning
  - Surveys: study skills (cognitive and meta-cognitive)
  - 3 Exams (35 multiple choice question)
  - Design Challenges
Design Challenge 1

Design Challenge 2

Participation Points

- Fall-Comparison
- Spring-Flipped

$d = .50$

$d = .13$

$d = .17$
Learning Summary

- No differences on post self-report survey for cognitive & metacognitive skills
- Gains for the flipped class on the later exams
- Large gain for the flipped class on DC-1 and small gains on DC-2 and participation points
Next steps

• More analysis…
  - taking into account prior performance and demographics;
    Propensity Score Matching
  - relations between motivation and learning

• Other measures:
  - in-class inquiry activity near the end of the semester
  - additional motivation, cognition, and metacognition survey items
  - open-ended survey questions: study strategies

• Changes going forward:
  - more quizzes, change grading structure of them?
  - add inquiry component to exam assessment?
Thank you

Graduate Teaching Assistants

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Undergraduate Teaching Assistants

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Gwen Hoeffgen
Amanda Hopcroft
Emily Wenz

Questions?