Teaching Students How to Succeed in Your Course

Spring 2023

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Center for Teaching
and Learning

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Warm up

Part I. Strategies

- What study strategies do you think are most effective?
- What study strategies do you think your students use?

Warm up

Part I. Strategies

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Part II. Studying FAQ
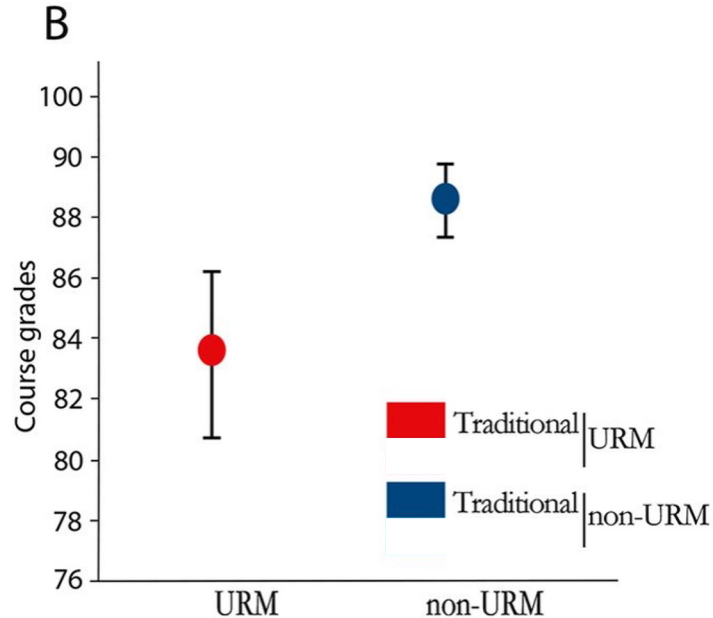
- Pgs 3-4 has a FAQ adapted from Meaders, 2021. Could something like this be useful for your students (if tailored for you class)?
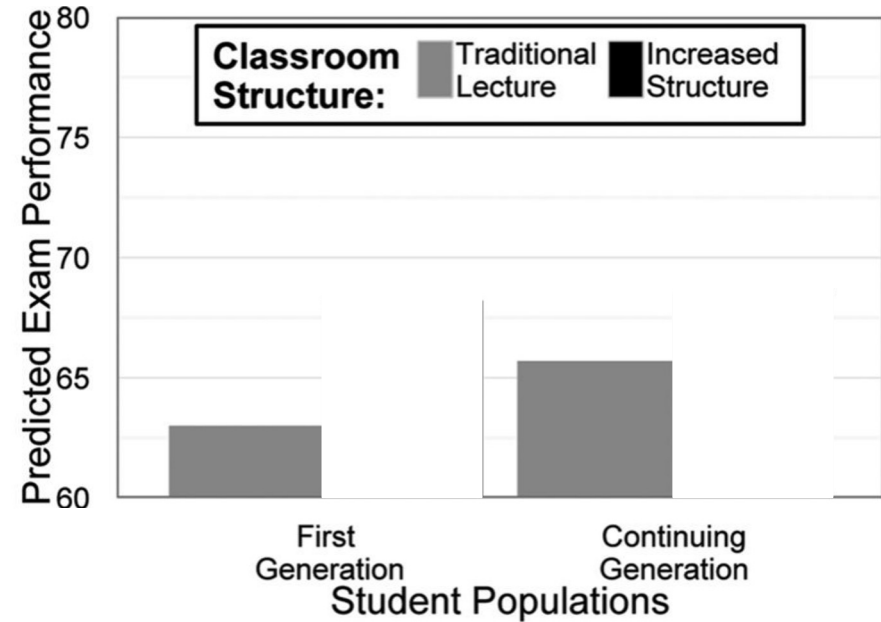
Rodriguez *et al.* (2018): Big Picture

1. Challenge: Persistent achievement gaps in STEM courses between historically **U**nder-**R**epresented **M**inorities (URM) students and non-URM students.
   - Despite work and attention to improving **classroom instruction**
   - Largely ignoring how URM and non-URM students **study outside of class**

1. Intervention: **Spacing** and **self-testing** are two study strategies that have been shown to be effective in laboratory settings
   - But little work has shown the effectiveness of these strategies in real classes

Rodriguez, Fernando et al. "How Do Students Study in STEM Courses? Findings from a Light-Touch Intervention and Its Relevance for Underrepresented Students." PloS one 13.7 (2018): e0200767–e0200767.

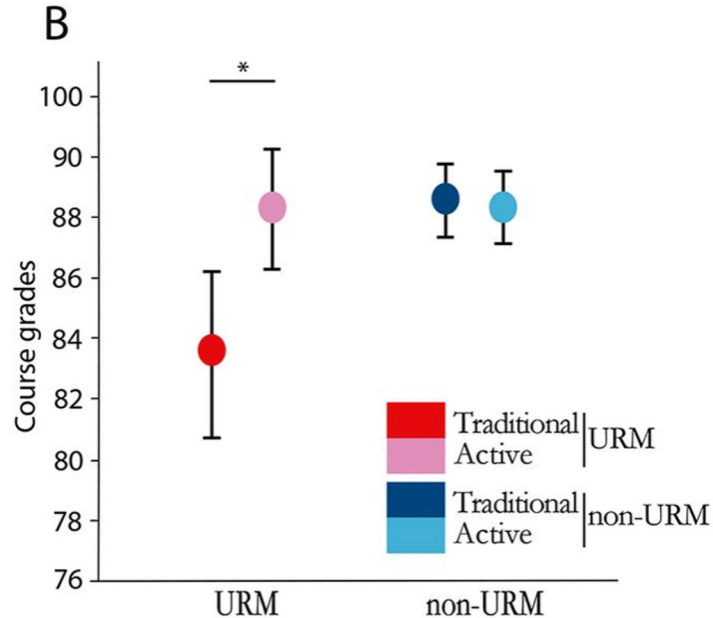# Attempts to decrease performance gaps by modifying class time

Ballen CJ, Wieman C, *et al*. "Enhancing Diversity in Undergraduate Science: Self-Efficacy Drives Performance Gains with Active Learning." CBE Life Sci Educ. 2017 Winter; 16 (4).

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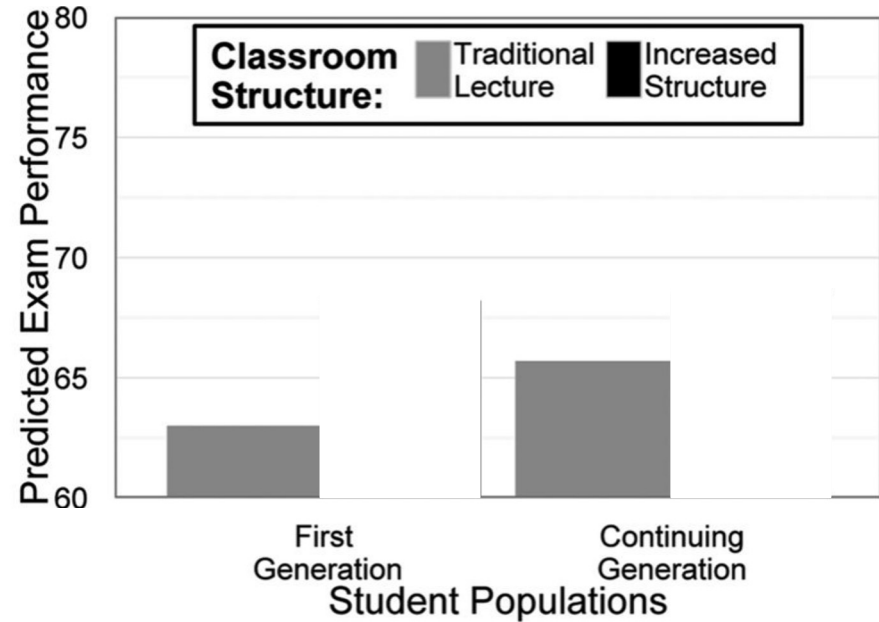

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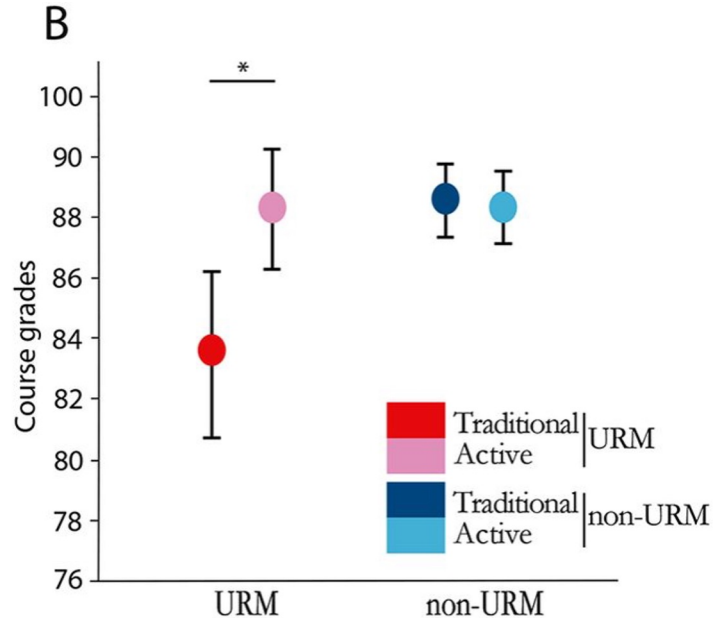# Attempts to decrease performance gaps by modifying class time

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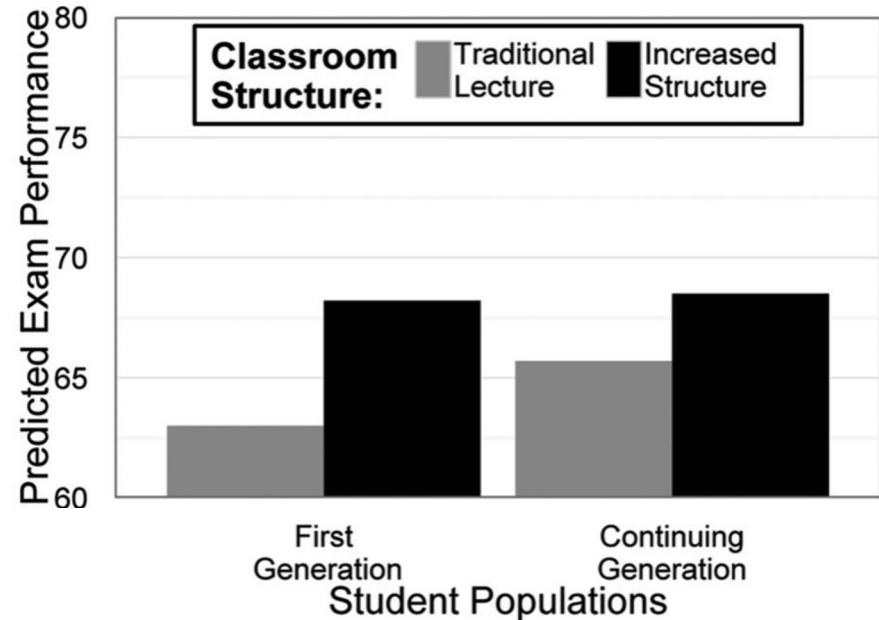
Eddy SL and Hogan KA. "Getting Under the Hood: How and for Whom Does Increasing Course Structure Work?" CBE Life Sciences Education. 2014; 13(3): 453-468.

"Achievement gap" definition in this article (retention):

% of students who entered college (in 2004) who wanted to graduate as STEM majors who did so within 6 years:
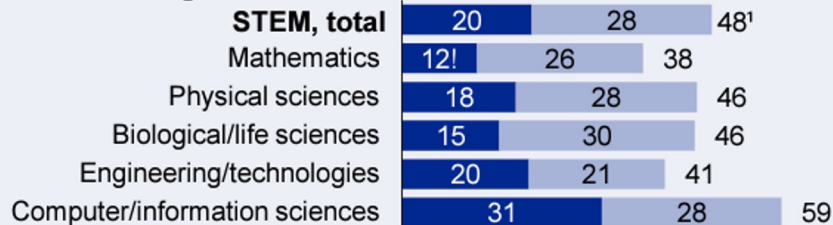
- 43% of White students
- 52% of Asian students
- 22% of Latino/a students
- 25% of African American students
- 25% of Native American students

Hurtado S, Eagan KM , & Hughes B. (2012) Priming the Pump or the Sieve: Institutional Contexts and URM STEM Degree Attainments. Annual Forum of the Association for Institutional Research, New Orleans, LA.

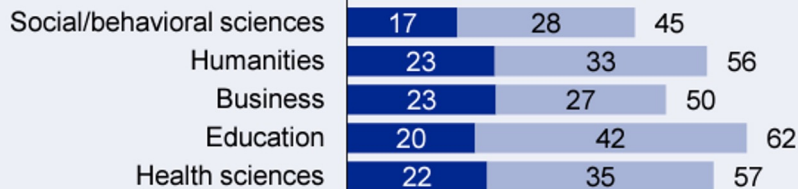# Overall trends of attrition, STEM vs non-STEM, within 5 yrs:

Figure 2.
Percentage of 2003–04 beginning bachelor's and associate's degree students who left STEM and selected non-STEM fields after their entrance into these fields, by major field entered: 2003–2009

Beginning bachelor's degree students

	Left PSE without a degree or certificate[2]	Switched to a different major field category	Total
STEM, total	20	28	48[1]
Mathematics	12!	26	38
Physical sciences	18	28	46
Biological/life sciences	15	30	46
Engineering/technologies	20	21	41
Computer/information sciences	31	28	59

Selected non-STEM fields

Social/behavioral sciences	17	28	45
Humanities	23	33	56
Business	23	27	50
Education	20	42	62
Health sciences	22	35	57

■ Left PSE without a degree or certificate[2]   ■ Switched to a different major field category

Chen and Soldner. (2013). STEM Attrition: College Students' Paths Into and Out of STEM Fields (NCES 2014-001). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC.

Rodriguez *et al.* (2018): Big Picture

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1. Intervention: **Spacing** and **self-testing** are two study strategies that have been shown to be effective in laboratory settings
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Spacing

Cramming / "Massed":
Study material all in one block

Spacing:
Study material in several, shorter sessions that are spaced apart from each other

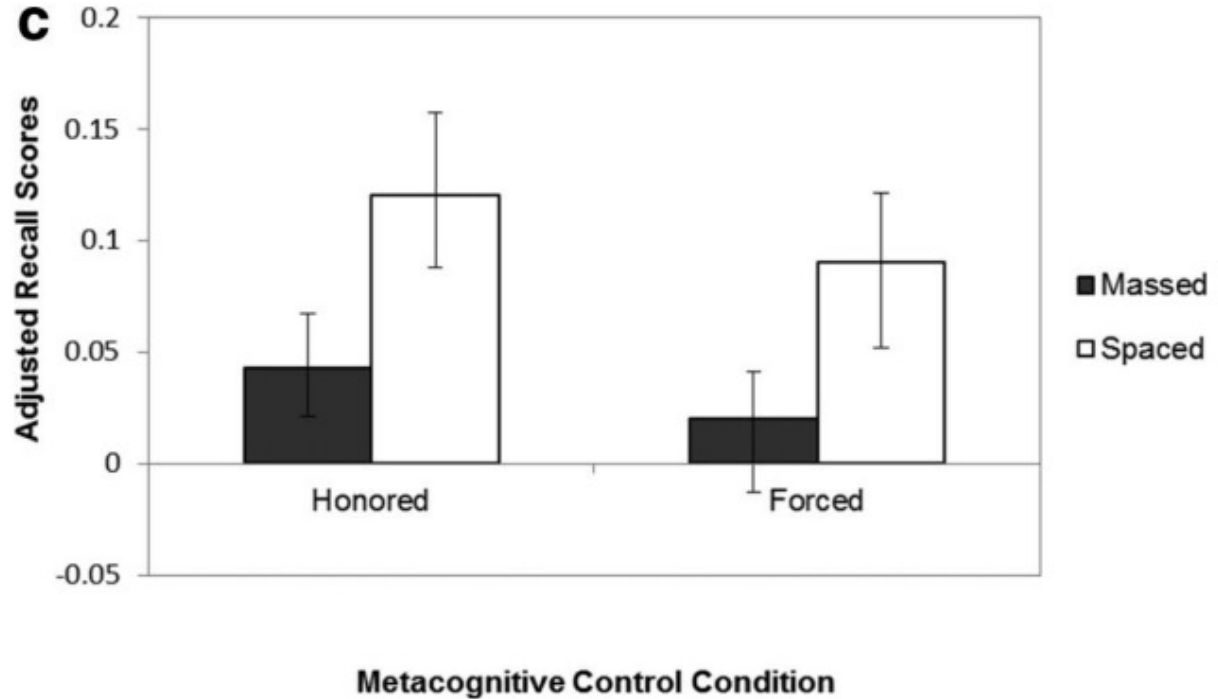| Session 1	Session 2	Session 3
Topic A		
Topic A	Topic A	Topic A

- Learners get multiple opportunities to review the material
- Learners tend to forget material between study sessions, leveraging the later refresher sessions

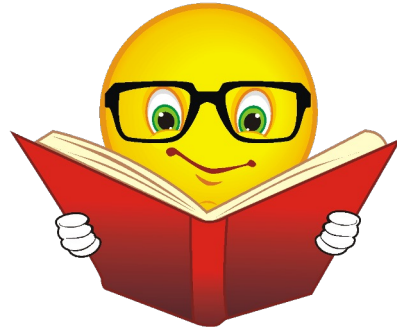# "**Spacing out**" learning improves long-term retention
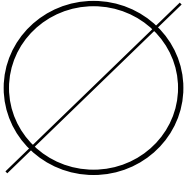
- UNC students

- 80 synonym pairs of GRE terms

Mulligan, Neil W, and Daniel J Peterson. "The Spacing Effect and Metacognitive Control." *Journal of experimental psychology. Learning, memory, and cognition* 40.1 (2014): 306–311.

Re: **Self-testing**

Imagine reading a half-page passage of text containing information on a single scientific topic once for 5 minutes.

Karpicke, Jeffrey D, and Janell R Blunt. "Retrieval Practice Produces More Learning Than Elaborative Studying with Concept Mapping." Science (American Association for the Advancement of Science) 331.6018 (2011): 772–775.

What percentage of factual information in the text do you think you could correctly recall after **7 days** if you took one of the following study approaches:
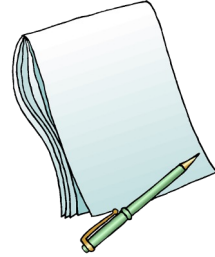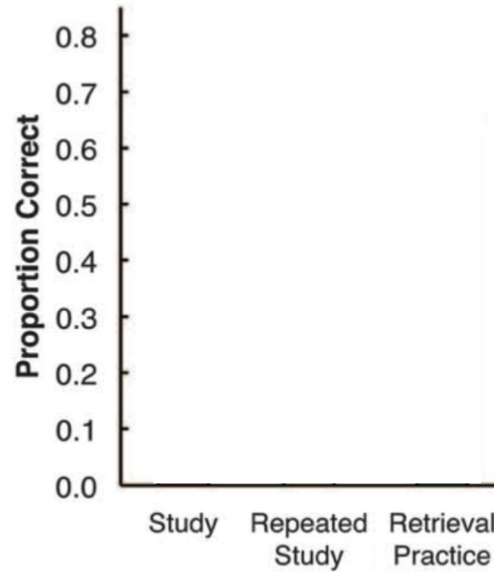
1.

2.

3.

No further studying
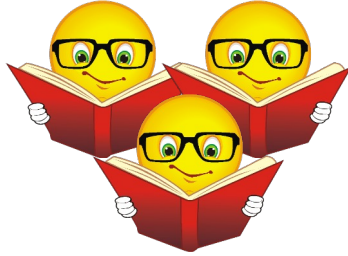
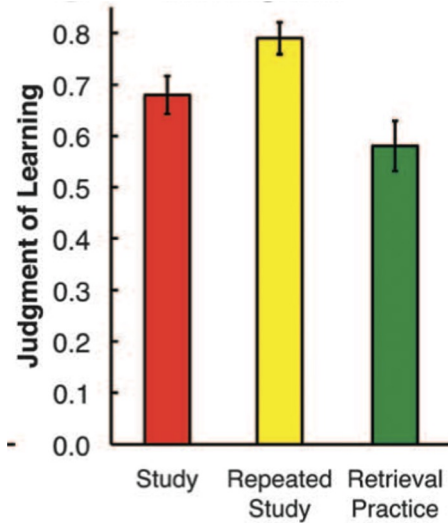**Repeated study (review):** re-read text three more times

Retrieval Write down everything you remember. Read text again, and then write down everything you remember a second time.

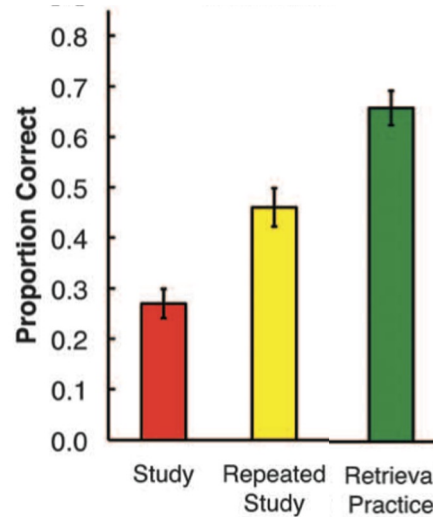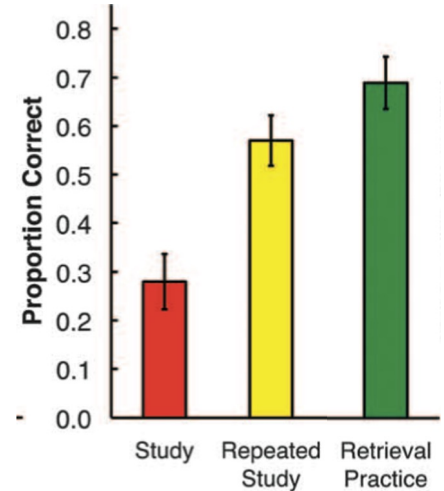Karpicke, Jeffrey D, and Janell R Blunt. "Retrieval Practice Produces More Learning Than Elaborative Studying with Concept Mapping." Science (American Association for the Advancement of Science) 331.6018 (2011): 772–775.

Sketch your prediction!

Karpicke, Jeffrey D, and Janell R Blunt. "Retrieval Practice Produces More Learning Than Elaborative Studying with Concept Mapping." Science (American Association for the Advancement of Science) 331.6018 (2011): 772–775.

Students' Predictions — **Verbatim Questions** — **Inference Questions**

We can often be poor judges of identifying the most successful strategies.

Karpicke, Jeffrey D, and Janell R Blunt. "Retrieval Practice Produces More Learning Than Elaborative Studying with Concept Mapping." Science (American Association for the Advancement of Science) 331.6018 (2011): 772–775.

Rodriguez *et al.* (2018): Big Picture

Methodology: examine students' study practices at the beginning and end of a sophomore-level bio class

1. Surveyed students at the beginning (wk 1) and end of the course (end of wk 10)

2. Course is taught in three sections: one was treated as the intervention group; two were used as controls
- Brian taught the intervention group:
  - Wk 2: 10 min mini-lecture on **spacing** and **self-testing**
  - Brian reminded students each week thereafter to use spacing and self-testing

Brian Sato

Rodriguez, Fernando et al. "How Do Students Study in STEM Courses? Findings from a Light-Touch Intervention and Its Relevance for Underrepresented Students." PloS one 13.7 (2018): e0200767–e0200767.

Students define themselves as using "spacing" and/or "self-testing": Survey (given Week 1 and Week 10)

1. Which of the following best describes your study patterns?
   - I most often space out my study sessions over multiple days/weeks ← **"yes"**
   - I most often do my studying right before the test ← **"no"**

"Spacing"

2 .Select the top 3 study strategies you use most regularly. Please select ONLY 3.
   - Test yourself with questions or practice problems ← **"Self-testing"** if listed as one of their top 3
   - Use flashcards
   - Reread chapters, articles, notes, etc.
   - Underlining or highlighting while reading
   - Recopy your notes word-for-word
   - Condensing/Summarizing your notes
   - Recopy your notes from memory
   - Make diagrams, charts, or pictures
   - Study with friends
   - Absorbing lots of information the night before the test
   - Watch/listen to recorded lessons either by instructor or from outside source (Khan Academy, Youtube, etc.).
   - Other

3. When studying, how do you generally decide what class to study for first? (open-ended)

Class demographics

	Year 1 Respondents (N = 544)		Year 2 Respondents (N = 782)	
	N	Mean (SD) / Percentage	N	Mean (SD) / Percentage
Age	544	20.67 (1.94)	782	20.76 (2.06)
Female	338/543	62.13%	503/777	64.73%
Male	205/543	37.75%	274/777	35.26%
Asian	316/544	58.08%	402/782	51.40%
White	105/544	19.30%	148/782	18.92%
Hispanic/Latino	66/544	12.13%	145/782	18.54%
International	32/544	5.88%	47/782	6.01%
Other/Unknown	25/544	4.59%	40/782	5.11%
URM[1]	80/544	14.70%	169/782	21.61%
First Generation	236/525	44.95%	372/759	49.01%
Low Income	176/544	32.35%	272/781	34.82%
1st Year	98/544	18.01%	168/782	21.48%
2nd Year	388/544	71.32%	508/782	64.96%
3rd Year	46/544	8.45%	92/782	11.76%
4th Year	11/544	2.02%	10/782	1.27%
5+ Years	1/544	0.00%	4/782	0.51%
SAT Total Score	463	1808.51 (205.52)	658	1789.80 (212.49)
High School GPA	433	4.06 (0.19)	600	4.06 (0.19)
Cumulative College GPA	544	3.28 (0.44)	782	3.20 (0.48)
Final Course Grade	544	7.99 (2.83)	782	8.21 (2.73)

Demographic data for students who completed both the pre- and post-surveys are listed above.

[1]Underrepresented minorities (URMs) were categorized as Hispanic/Latino, African American, and Native American. Descriptive information for African American and Native American students are not reported individually due to small sample sizes and are categorized as Other/Unknown in this table. Final Course Grade ranged from 1 (F) to 13 (A+).

https://doi.org/10.1371/journal.pone.0200767.t001

Overall pre-survey

		Overall (N = 1,326)
Study Patterns		
	Spacing	56.71%
Study Strategies		
	Self-Testing	65.00%
	Re-Read Chapters	56.03%
	Watch Video Lectures	30.31%
	Condense Notes	31.29%
	Make Diagrams	23.30%
	Study with Friends	20.58%
	Highlight/Underline Text	19.45%
	Flashcards	19.15%
	Recopy Notes	9.80%
	Recopy Notes from Memory	6.18%
	Other	1.35%

Pre-course survey patterns: URM vs non-URM
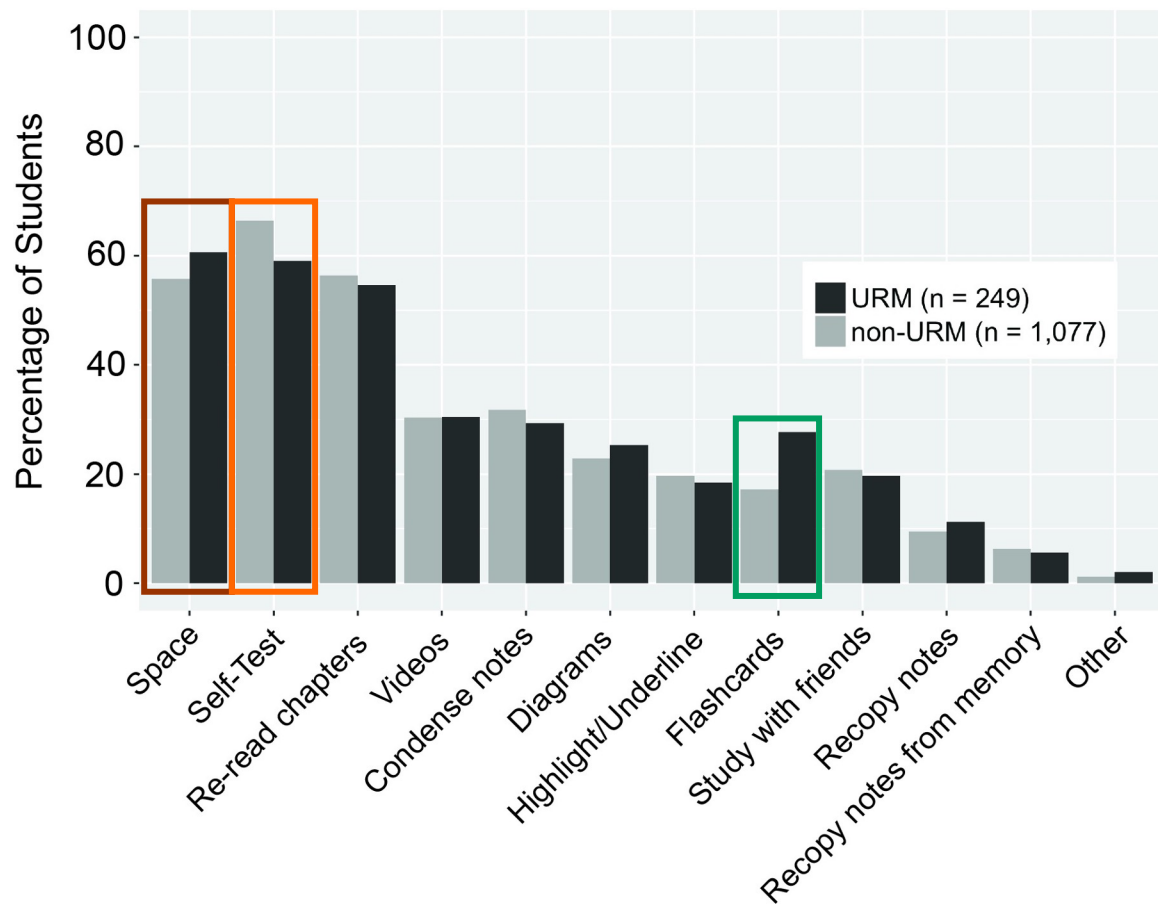
Impact of intervention on self-reported use of **spacing**

A.
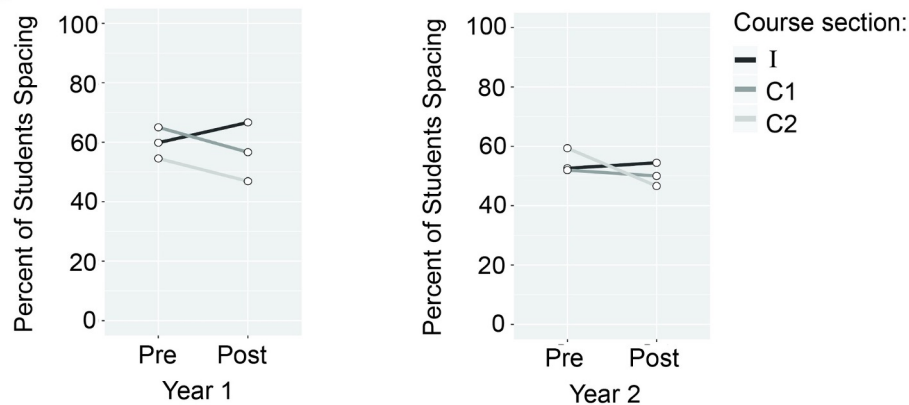
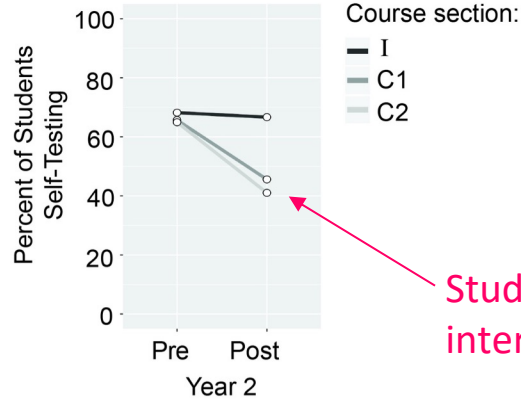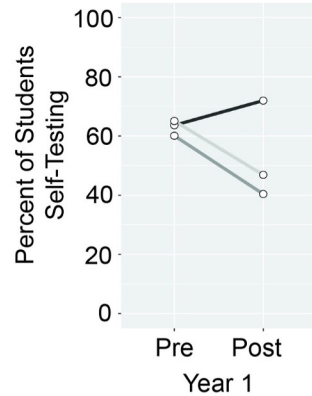Intervention groups increase use of spacing,
Control groups decrease
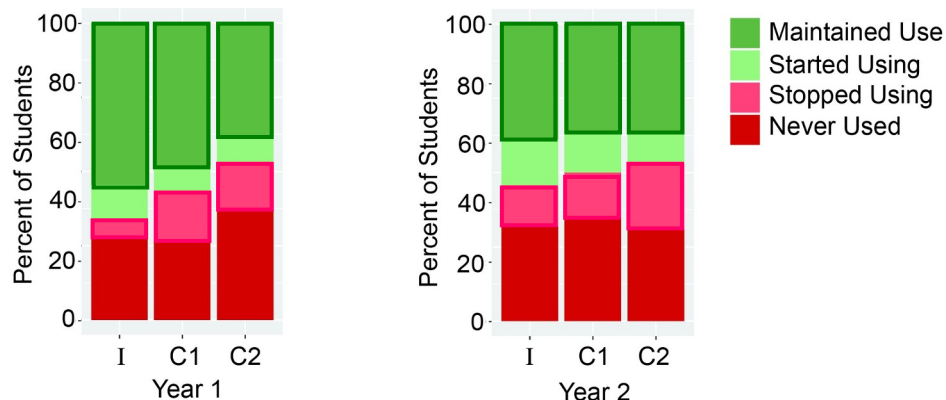
Pre	→	Post
Yes	→	Yes
No	→	Yes
Yes	→	No
No	→	No

Post-hoc analysis

B.

Impact of a intervention on students' self-reported **self-testing.**
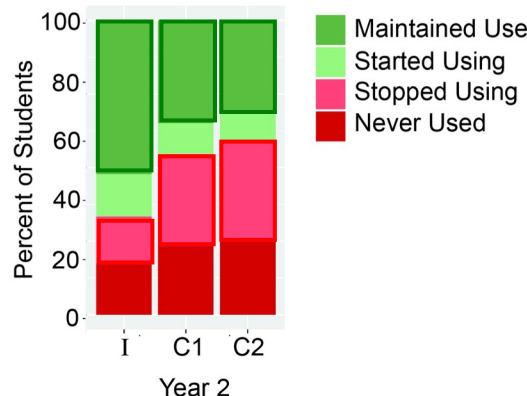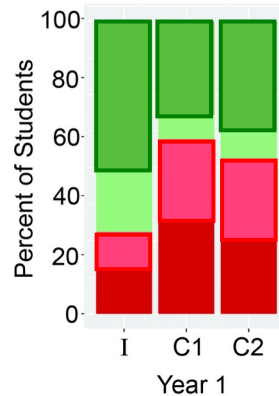

A.

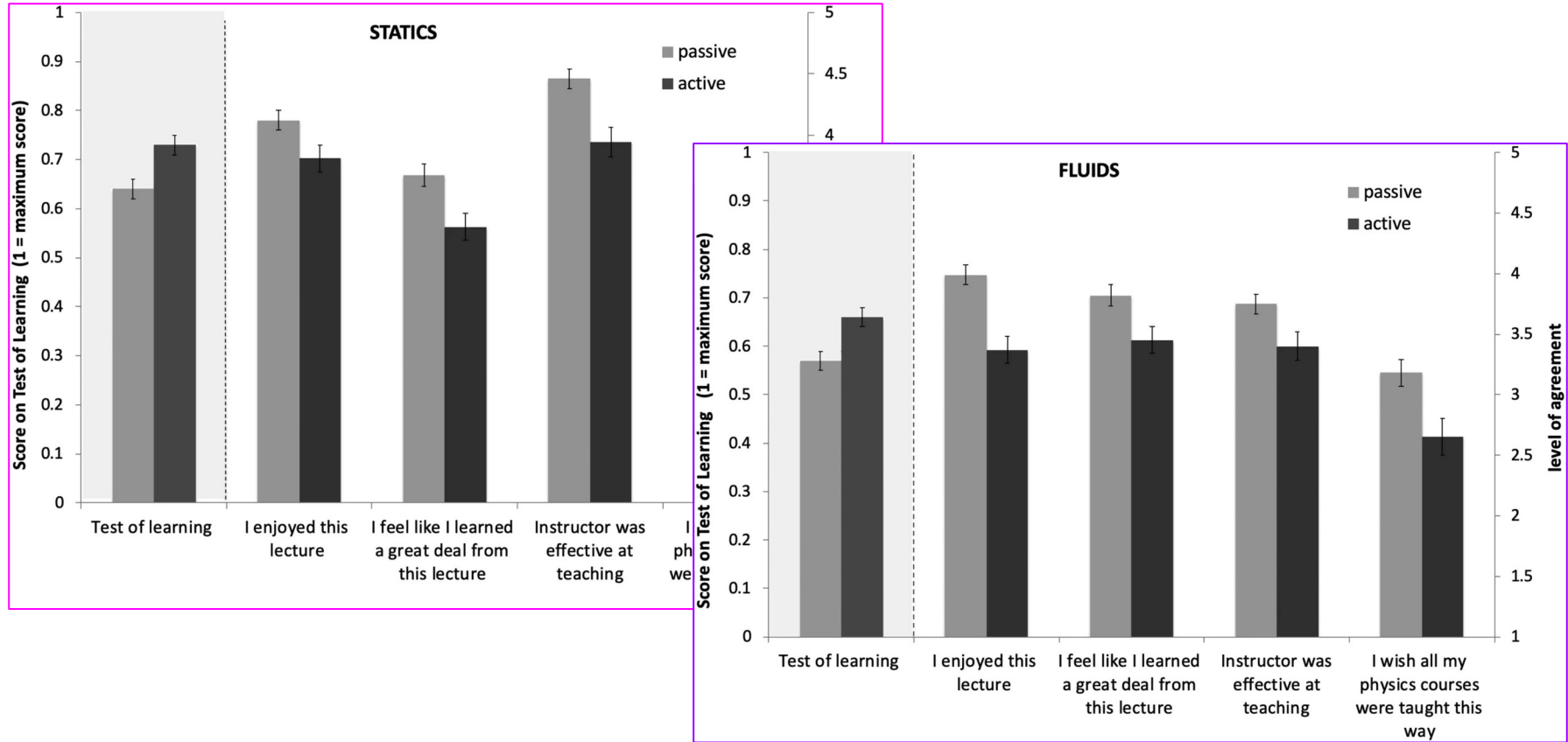Intervention groups use self-testing significantly more than control groups.

Students dropped self-study w/o intervention

Pre	→	Post
Yes	→	Yes
No	→	Yes
Yes	→	No
No	→	No

B.

Maintained Use
Started Using
Stopped Using
Never Used

Active Learning in Intro Physics for Majors

Deslauriers, Louis *et al*. "Measuring Actual Learning Versus Feeling of Learning in Response to Being Actively Engaged in the Classroom." Proceedings of the National Academy of Sciences - PNAS 116.39 (2019): 19251–19257.

Does changing students' study strategies matter (**re: course grade**)?

|	Year 1 (n = 544)				Year 2 (n = 782)			
	Used Strategy		Did not Use	t		Used Strategy		Did not Use	t
		Grade	Grade				Grade	Grade	
	%	M (SD)	M (SD)			%	M (SD)	M (SD)	
Study Patterns									
Spacing	55.33%	8.32 (2.63)	7.58 (3.01)	2.99**	**3**	50.76%	8.60 (2.71)	7.80 (2.69)	4.16***	**2**
Study Strategies									
Self-Testing	50.55%	8.29 (2.70)	7.69 (2.92)	2.46**	**2**	52.94%	8.61 (2.66)	7.76 (2.74)	4.40***	**1**
Re-Read Chapters	66.91%	7.79 (2.84)	8.40 (2.76)	-2.37*		59.20%	8.14 (2.69)	8.30 (2.79)	-0.77	
Watch Video Lectures	28.30%	7.93 (2.85)	8.02 (2.82)	-0.31		31.32%	8.04 (2.75)	8.29 (2.72)	-1.17	
Condense Notes	38.41%	8.48 (2.67)	7.69 (2.88)	3.25**	**1**	39.64%	8.52 (2.70)	8.00 (2.73)	2.64**	**4**
Make Diagrams	16.36%	8.51 (2.47)	7.89 (2.88)	2.10*	**4**	18.92%	8.81 (2.51)	8.07 (2.76)	3.15**	**3**
Study with Friends	19.66%	8.17 (2.71)	7.95 (2.85)	0.76		25.95%	8.32 (2.58)	8.17 (2.78)	0.67	
Highlight/Underline Text	27.02%	7.74 (2.97)	8.09 (2.77)	-1.24		21.99%	7.78 (2.83)	8.33 (2.69)	-2.26*	
Flashcards	12.13%	7.09 (2.83)	8.12 (2.81)	-2.77**		7.03%	7.00 (2.83)	8.30 (2.70)	-3.30***	
Recopy Notes	9.00%	7.55 (3.05)	8.04 (2.80)	-1.10		13.42%	7.34 (2.79)	8.34 (2.70)	-3.44***	
Recopy Notes from Memory	2.88%	7.84 (3.02)	8.00 (2.82)	-0.30		5.75%	7.53 (3.18)	8.25 (2.70)	-1.48	

Final course grade was examined in the context of the particular study strategies students stated they used on the post-survey. For each study strategy, t-tests were used to compare grade differences between students who reported utilizing the study strategy compared to students who did not report using the strategy. Course grades were converted to numerical values for this analysis ranging from A+ (13) to F (1).

* $p < .05$

** $p < .01$

*** $p < .001$

URM and non-URM students who report self-testing earned the same course grades
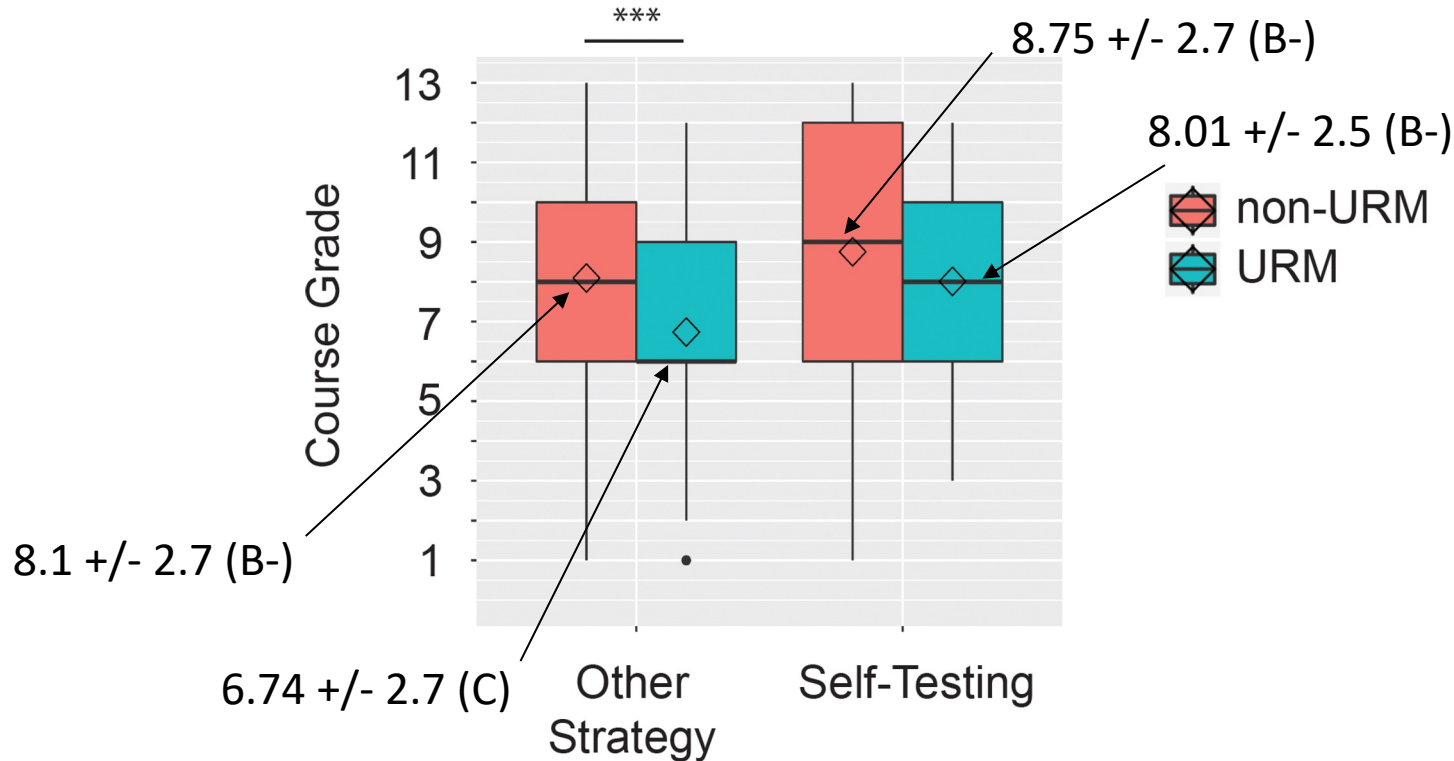
Prior research: survey of 177 college students

Open-ended question: List the strategies you use when studying

METACOGNITIVE STRATEGIES IN LEARNING   475

TABLE 1
Results of Question 1

Strategy	Percent who list strategy		Percent who rank as #1 strategy		Mean rank
1. Rereading notes or textbook	83.6	(148)	54.8	(97)	1.5
2. Do practice problems	42.9	(76)	12.4	(22)	2.1
3. Flashcards	40.1	(71)	6.2	(11)	2.6
4. Rewrite notes	29.9	(53)	12.4	(22)	1.8
5. Study with a group of students	26.5	(47)	0.5	(1)	2.9
6. "Memorise"	18.6	(33)	5.6	(10)	2.0
7. Mnemonics (acronyms, rhymes, etc)	13.5	(24)	2.8	(5)	2.4
8. Make outlines or review sheets	12.9	(23)	3.9	(7)	2.1
9. Practise recall (self-testing)	10.7	(19)	1.1	(2)	2.5
10. Highlight (in notes or book)	6.2	(11)	1.6	(3)	2.3
11. Think of real life examples	4.5	(8)	0.5	(1)	2.8

Percent of students listing different learning strategies, percent who ranked strategies as their #1 strategy, and mean rankings of strategies. Raw numbers of students are in parentheses.
Mean number of strategies listed was 2.9 ($SD=0.96$). Percentages of students indicating their #1 strategy do not add to 100% because some students merged multiple strategies when reporting their #1 strategy (e.g., indicating that rereading and rewriting notes were their #1 strategy).

Karpicke JD, Butler AC, and Roediger HL 3rd. "Metacognitive strategies in student learning: do students practise retrieval when they study on their own?" Memory. 2009 May;17(4):471-9.

Summary

- Used a "light-touch" study skills intervention (10 min mini lecture in wk 2 and weekly reminders) to encourage students to use spacing and self-testing when studying
- Students who received intervention were more likely to begin or continue using spacing and self-testing
- URM students who self-test earn similar grades to non-URM students who self-test
  - URM students who did not self test had significantly lower grades than non-URM students who did not self test
- Condensing notes and Making Diagrams are also effective study techniques!

Dunlosky *et al*., 2013

Table 4. Utility Assessment and Ratings of Generalizability for Each of the Learning Techniques

Technique	Utility	Learners	Materials	Criterion tasks	Issues for implementation	Educational contexts
Elaborative interrogation	Moderate	P-I	P	I	P	I
Self-explanation	Moderate	P-I	P	P-I	Q	I
Summarization	Low	Q	P-I	Q	Q	I
Highlighting	Low	Q	Q	N	P	N
The keyword mnemonic	Low	Q	Q	Q-I	Q	Q-I
Imagery use for text learning	Low	Q	Q	Q-I	P	I
Rereading	Low	I	P	Q-I	P	I
Practice testing	High	P-I	P	P	P	P
Distributed practice	High	P-I	P	P-I	P	P-I
Interleaved practice	Moderate	I	Q	P-I	P	P-I

Not Recommended (Summarization through Rereading)

Recommended (Practice testing through Interleaved practice)

Note: A positive (P) rating indicates that available evidence demonstrates efficacy of a learning technique with respect to a given variable or issue. A negative (N) rating indicates that a technique is largely ineffective for a given variable. A qualified (Q) rating indicates that the technique yielded positive effects under some conditions (or in some groups) but not others. An insufficient (I) rating indicates that there is insufficient evidence to support a definitive assessment for one or more factors for a given variable or issue.

Dunlosky, John et al. "Improving Students' Learning With Effective Learning Techniques: Promising Directions From Cognitive and Educational Psychology." *Psychological science in the public interest* 14.1 (2013).

Dunlosky *et al.*, 2013
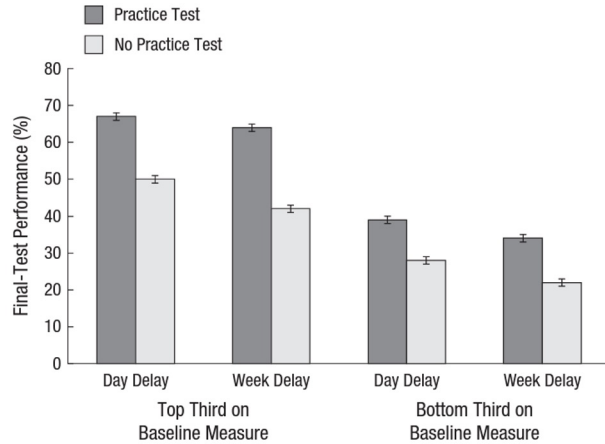
Fig. 7. Mean accuracy on a final test administered 1 day or 1 week after a learning session that either did or did not include a practice test, for the top and bottom thirds of scorers on a baseline measure of ability, in Spitzer (1939). Error bars represent standard errors.
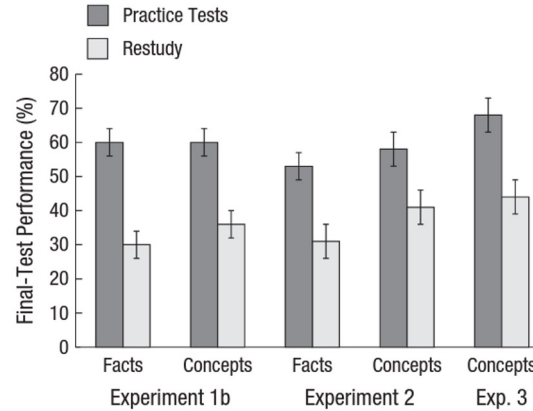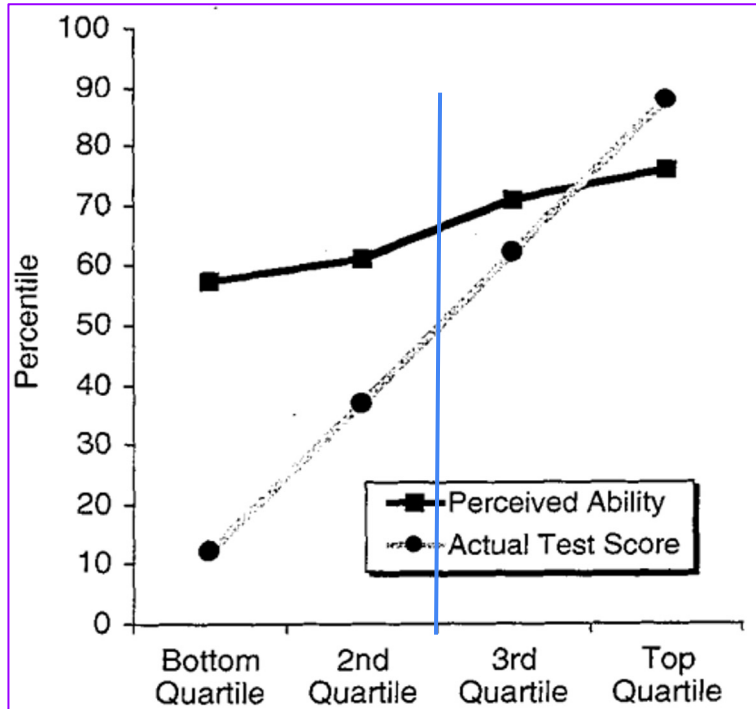
Fig. 8. Accuracy on final tests that consisted of inference-based transfer questions tapping key facts or concepts, administered 1 week after a learning session that involved either practice tests or restudy, in Butler (2010). Error bars represent standard errors.
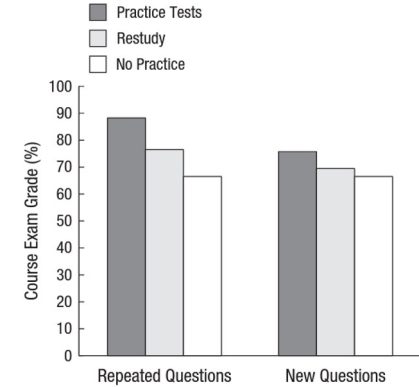
Fig. 9. Grades on course exams covering items that were presented for practice testing, presented for restudy, or not presented during online learning activities that students completed for course points. The course exam included some questions that had been presented during practice tests as well as new questions tapping the same information. For simplicity, outcomes reported here are collapsed across two experiments reported by McDaniel, Wildman, and Anderson (2012).

Dunlosky, John et al. "Improving Students' Learning With Effective Learning Techniques: Promising Directions From Cognitive and Educational Psychology." *Psychological science in the public interest* 14.1 (2013).

Dunning Kruger Effect: **The Illusion of Knowing**

What is true of the students on the left?

"why incompetent people think they're amazing…"

→ why inexpert students need help developing learning skills

Kruger J and Dunning D. "Unskilled and unaware of it: how difficulties in recognizing one's own incompetence lead to inflated self-assessments." <u>J Pers Soc Psychol</u>. 1999 Dec; 77(6):1121-34.

Weekly Learning Paragraphs (an example of retrieval practice):

-Due every Friday at 10 am

-Respond to question posted on web

Learning 4/28/08

Page **1** of 1

What is the one concept you learned this week that was the most challenging to master? Please also explain why it is challenging for you.

Submit responses   Cancel

Questions or Comments?
Contact Mary Pat Wenderoth at mpw@u.washington.edu

powered by WebQ

Example of Framework: Monthly Summary Sheets

Mary Pat Wenderoth
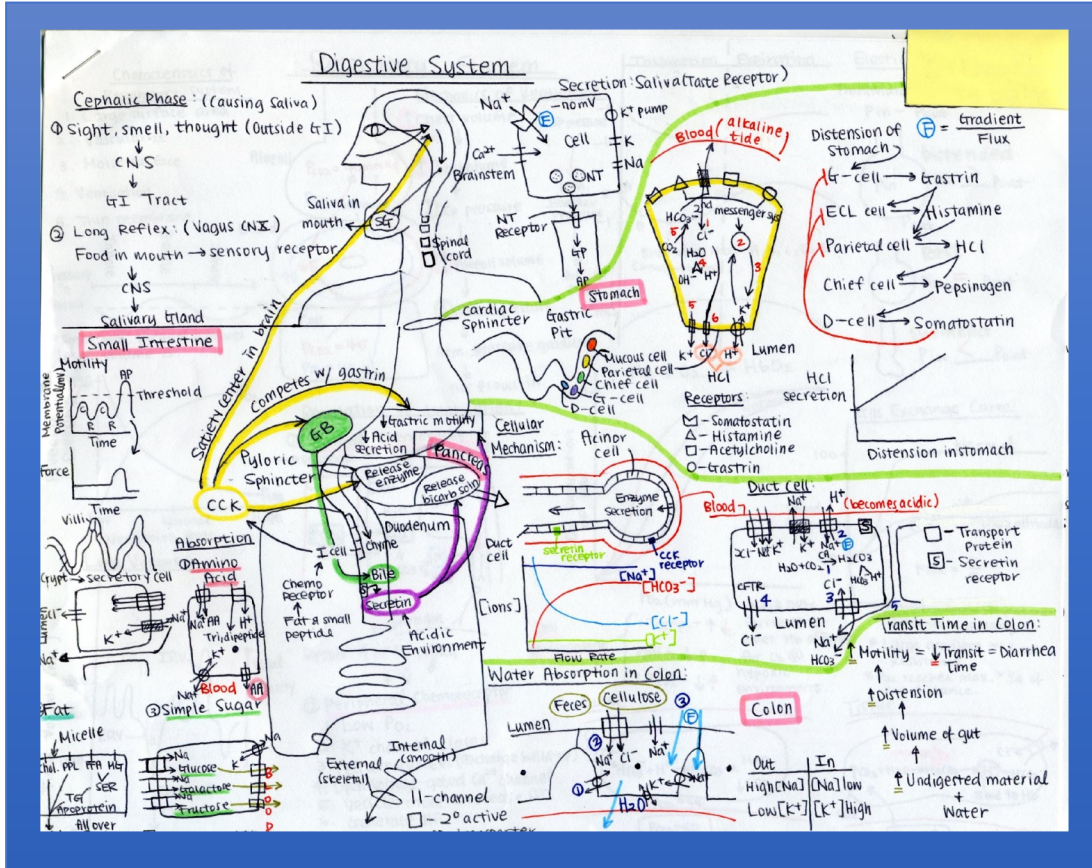
Think-Pair-Share

How can you prompt your students to use self-testing for your class?

Is it more effective to study a lot of problems of one type, or to vary your practice?

Approach 1:
Study material of all one type at a time

BLOCKED

A A A   B B B   C C C
A A A   B B B   C C C
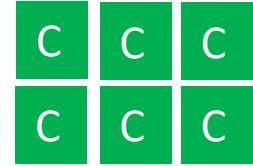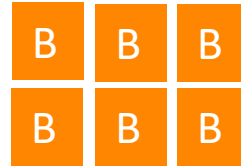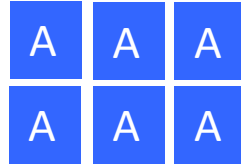
Approach 2:
Mix up the material you are studying

INTERLEAVED

A B C   C A B   C B A
C A B   A C B   B A C

Which do you think is a more effective strategy?

Which strategy do you think students prefer?

For example, see Rohrer and Taylor, Instr Sci 2007, 35(6): 481-498; Birnbaum, Kornell, Bjork, & Bjork (2012) *Memory & Cognition*
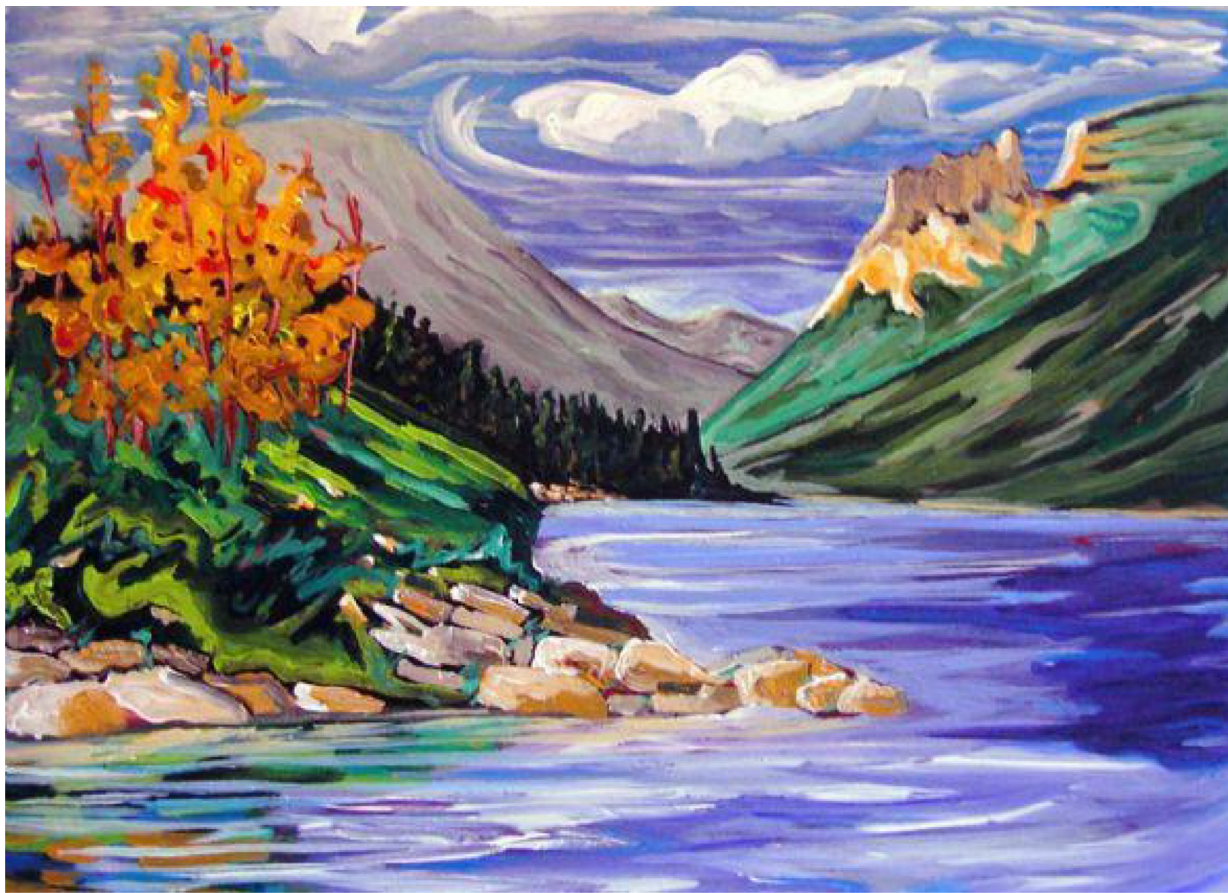
How would you study to identify which artist painted this painting?

Kornell, Nate, and Robert A. Bjork. "Learning Concepts and Categories: Is Spacing the 'Enemy of Induction'?" *Psychological science* 19.6 (2008): 585–592.

Which study strategy (1 or 2) do you think would help you better learn the artists' styles?

Condition 1: "Interleaved"

Condition 2: "Blocked"

B One painting by each of the six different artists

… x4 = 24 total paintings

A Six paintings by one of the artists

… x4 = 24 total paintings

Rohrer, Doug. "Interleaving Helps Students Distinguish Among Similar Concepts." Educational psychology review 24.3 (2012): 355–367.

Students' Predictions

Results:

Adapted from Kornell, Nate, and Robert A. Bjork. "Learning Concepts and Categories: Is Spacing the 'Enemy of Induction'?" *Psychological science* 19.6 (2008): 585–592.
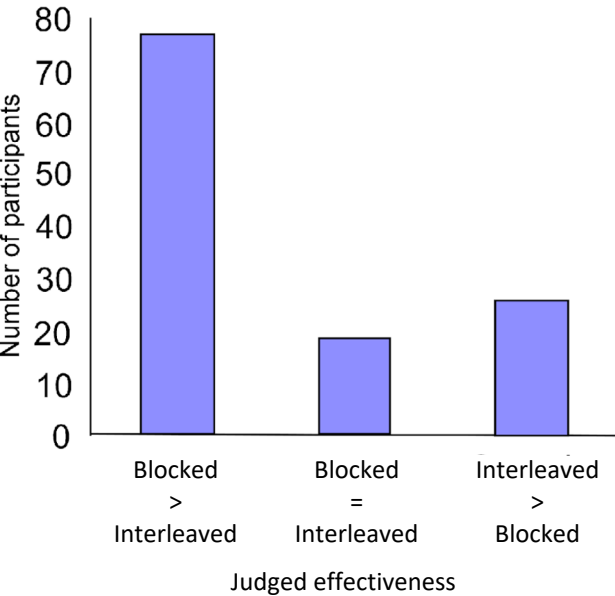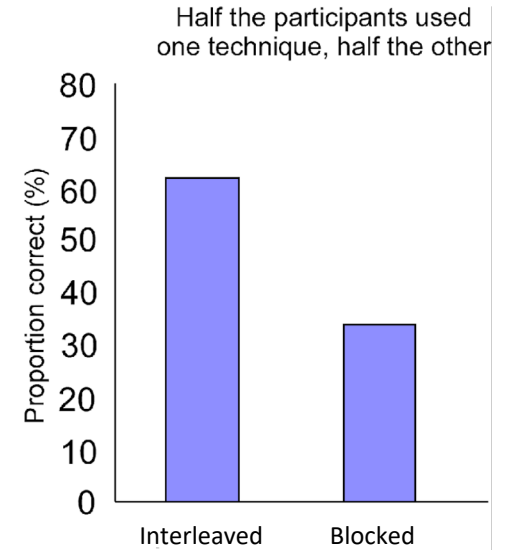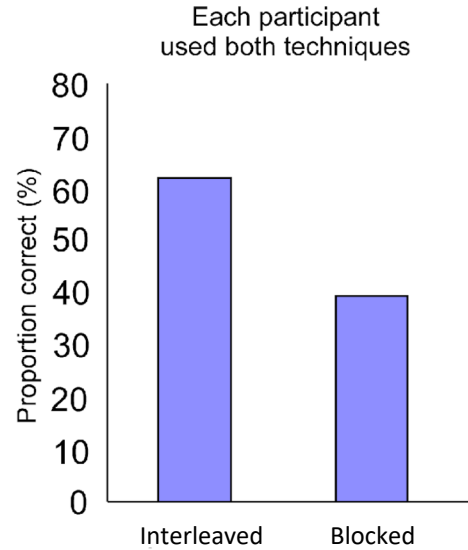
"**Interleaving**" (mixing up practice problems)

A Six paintings by one of the artists

B One painting by each of the six different artists

Rohrer, Doug. "Interleaving Helps Students Distinguish Among Similar Concepts." Educational psychology review 24.3 (2012): 355–367.
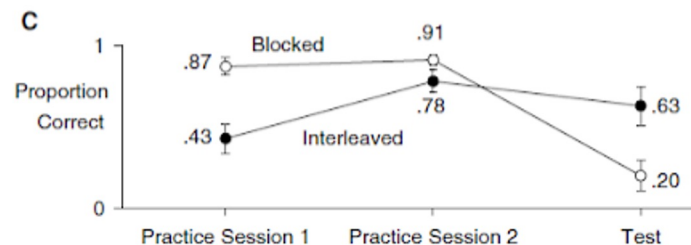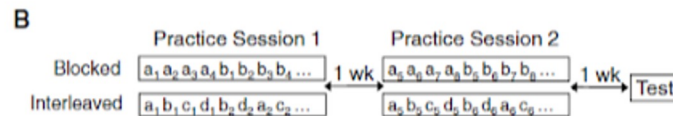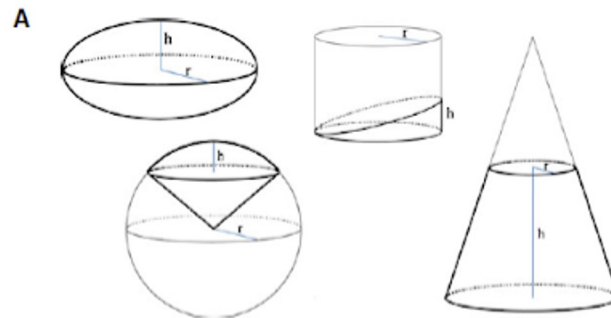
"Desirable Difficulties"

Test yourself ("self-testing" or "retrieval practice")

Space your practice

Mix up your practice (interleaving)

Think about a class that you might teach:
What are ways that you could implement some of these principles in your class?

Using Metacognition to Become an Expert Learner in [Chemistry]

(These slides are adapted from those that can be found under the "Resources" tab here:
https://styluspub.presswarehouse.com/browse/book/9781620363164/Teach-Students-How-to-Learn#additional)

Saundra McGuire
Presidential Award
White House Oval Office
November 16, 2007
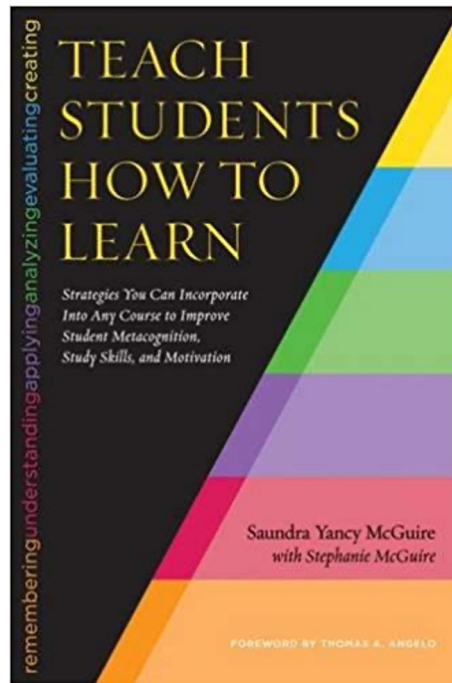
"Great explanations are only one arm of effective teaching. The other arm involves **teaching students how to learn material on their own, without help.**"

"Teaching students how to learn entails **opening their eyes to the learning *process*** and introducing them to the myriad strategies they can use to increase their learning."

"I now know that there are **students who have an arsenal of strategies** at their disposal and there are students who don't."

Metacognition

The ability to:

- think about thinking

- be consciously aware of oneself as a problem solver

- monitor and control one's mental processing (e.g. "Am I understanding this material?")
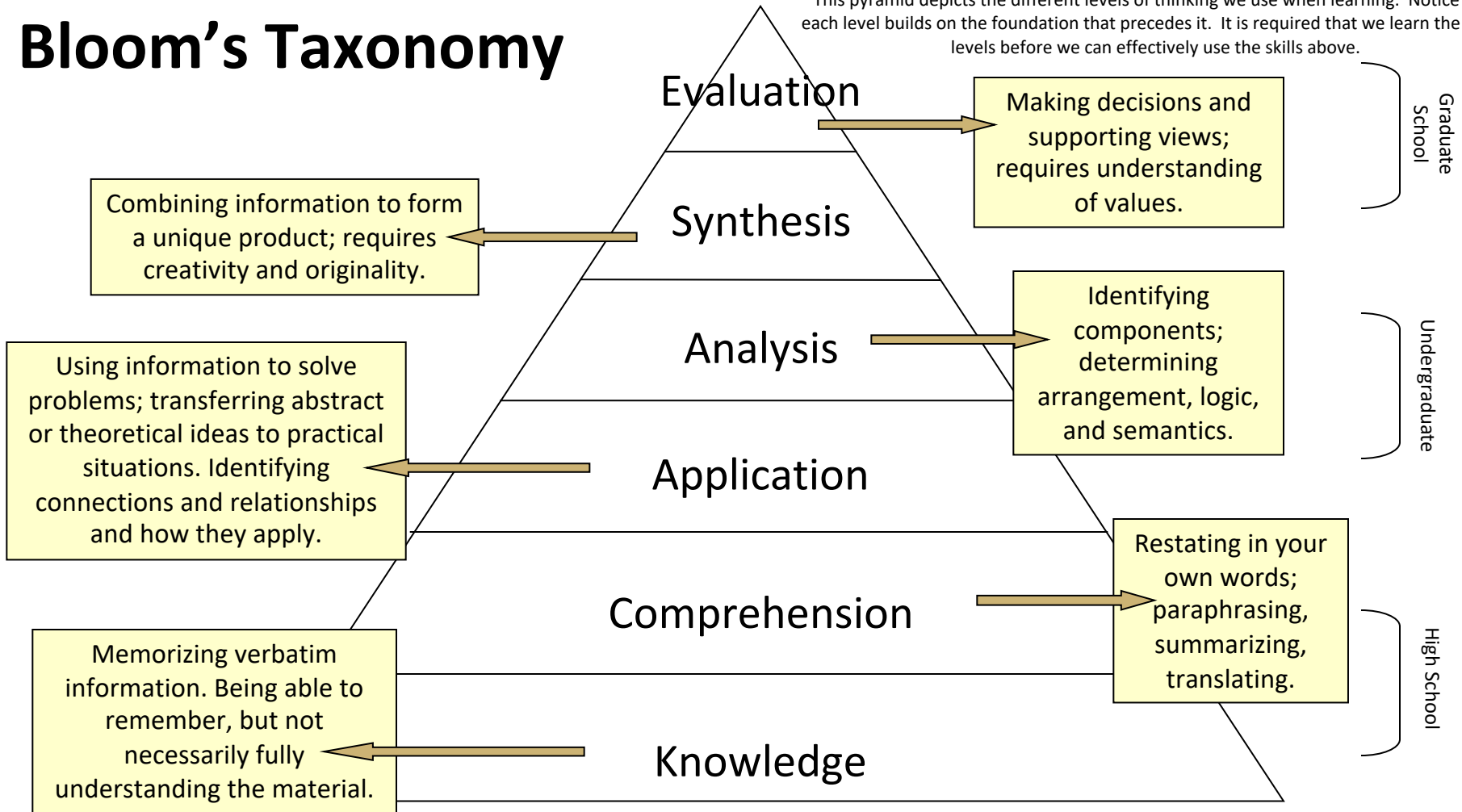
- accurately judge one's level of learning

Turning Yourself into an Efficient, Expert Learner

- Do "think aloud" exercises

- Constantly ask yourself "Why," "How," and "What if" questions

- Always test your understanding by verbalizing or writing about concepts; practice retrieval of information

- Move your activities higher on the **Bloom's taxonomy** scale by comparing and contrasting, thinking of analogies, thinking of new pathways, etc.
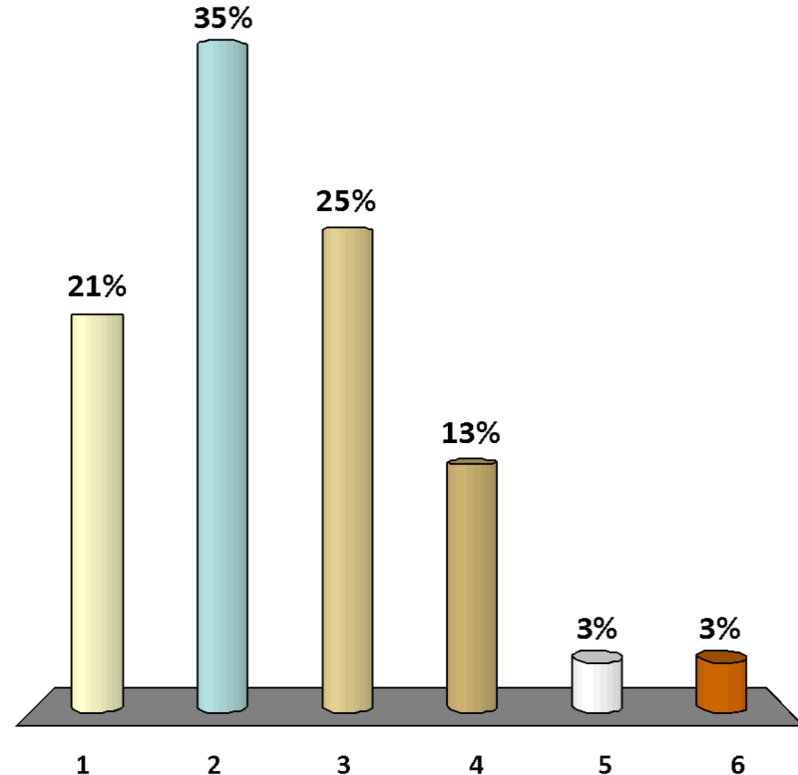
Bloom's Taxonomy

This pyramid depicts the different levels of thinking we use when learning. Notice how each level builds on the foundation that precedes it. It is required that we learn the lower levels before we can effectively use the skills above.

Evaluation

Making decisions and supporting views; requires understanding of values.

Graduate School

Synthesis

Combining information to form a unique product; requires creativity and originality.

Analysis

Identifying components; determining arrangement, logic, and semantics.

Undergraduate

Application

Using information to solve problems; transferring abstract or theoretical ideas to practical situations. Identifying connections and relationships and how they apply.

Comprehension

Restating in your own words; paraphrasing, summarizing, translating.

High School

Knowledge

Memorizing verbatim information. Being able to remember, but not necessarily fully understanding the material.

At what level of Bloom's did you have to operate to make A's or B's in high school?

1. Knowledge
2. Comprehension
3. Application
4. Analysis
5. Synthesis
6. Evaluation

At what level of Bloom's do you think you'll need to be to make an A in Chem 1201?

1. Knowledge

2. Comprehension

3. Application
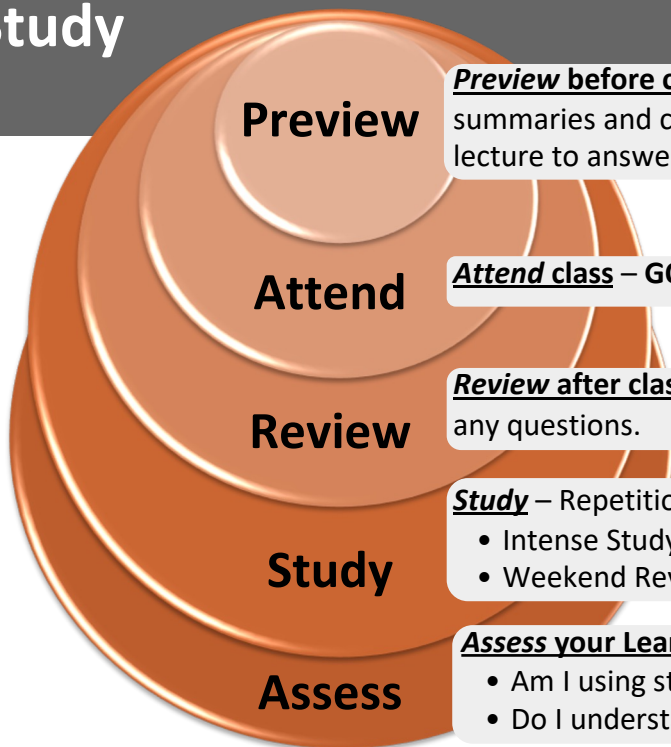
4. Analysis

5. Synthesis

6. Evaluation
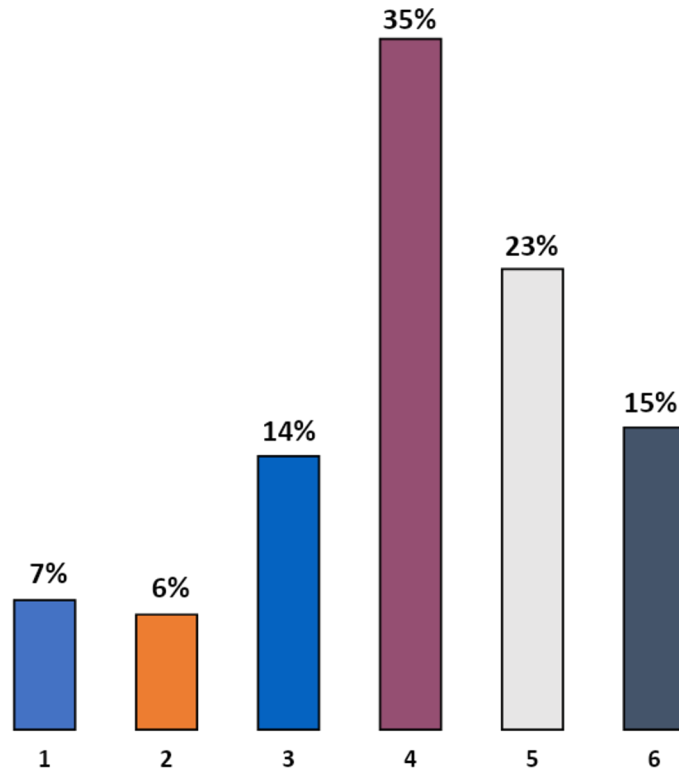
How do you move yourself **higher** on Bloom's Taxonomy?

Use the Study Cycle!

The Study Cycle

Preview

**Preview** before class – Skim the chapter, note headings and boldface words, review summaries and chapter objectives, and come up with questions you'd like the lecture to answer for you.

Attend

**Attend** class – **GO TO CLASS!** Answer and ask questions and take meaningful notes.

Review

**Review** after class – As soon after class as possible, read notes, fill in gaps and note any questions.

Study

**Study** – Repetition is the key. Ask questions such as "why", "how", and "what if".
- Intense Study Sessions* – 3-5 short study sessions per day
- Weekend Review – Read notes and material from the week to make connections

Assess

**Assess** your Learning – Periodically perform reality checks
- Am I using study methods that are effective?
- Do I understand the material enough to teach it to others?

*Intense Study Sessions

1	Set a Goal	(1-2 min)	**Decide what you want to accomplish in your study session.**
2	Study with Focus	(30-50 min)	**Interact with material-** organize, concept map, summarize, process, re-read, fill-in notes, reflect, etc.
3	Reward Yourself	(10-15 min)	**Take a break**– call a friend, play a short game, get a snack
4	Review	(5 min)	**Go over what you just studied**

Center for Academic Success
B-31 Coates Hall ▪ 225.578.2872 ▪www.cas.lsu.edu

Effective Metacognitive Strategies

- Always solve problems without looking at an example or the solution

- Memorize everything you're told to memorize (e.g. polyatomic ions)

- Always ask why, how, and what if questions

- Test understanding by giving "mini lectures" on concepts

- Spend time on chemistry every day

- Use the Study Cycle with Intense Study Sessions

- Attend SI sessions on a regular basis

- Aim for 100% mastery, not 90%!

Concept maps facilitate development of higher order thinking skills

Chapter Map

Compare and Contrast

Concept #1 **Concept #2**

How are they similar?

_____

_____

_____

_____
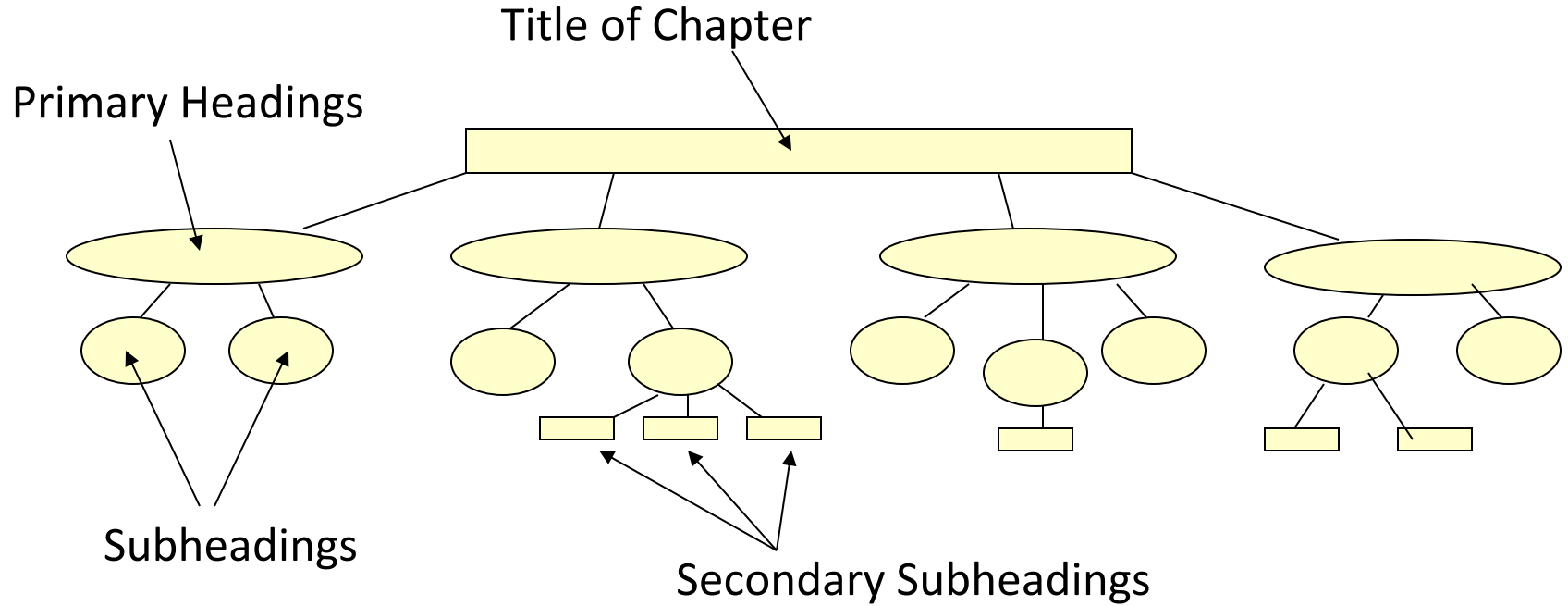
How are they different?

_____   _____

_____   _____

_____   _____

_____   _____
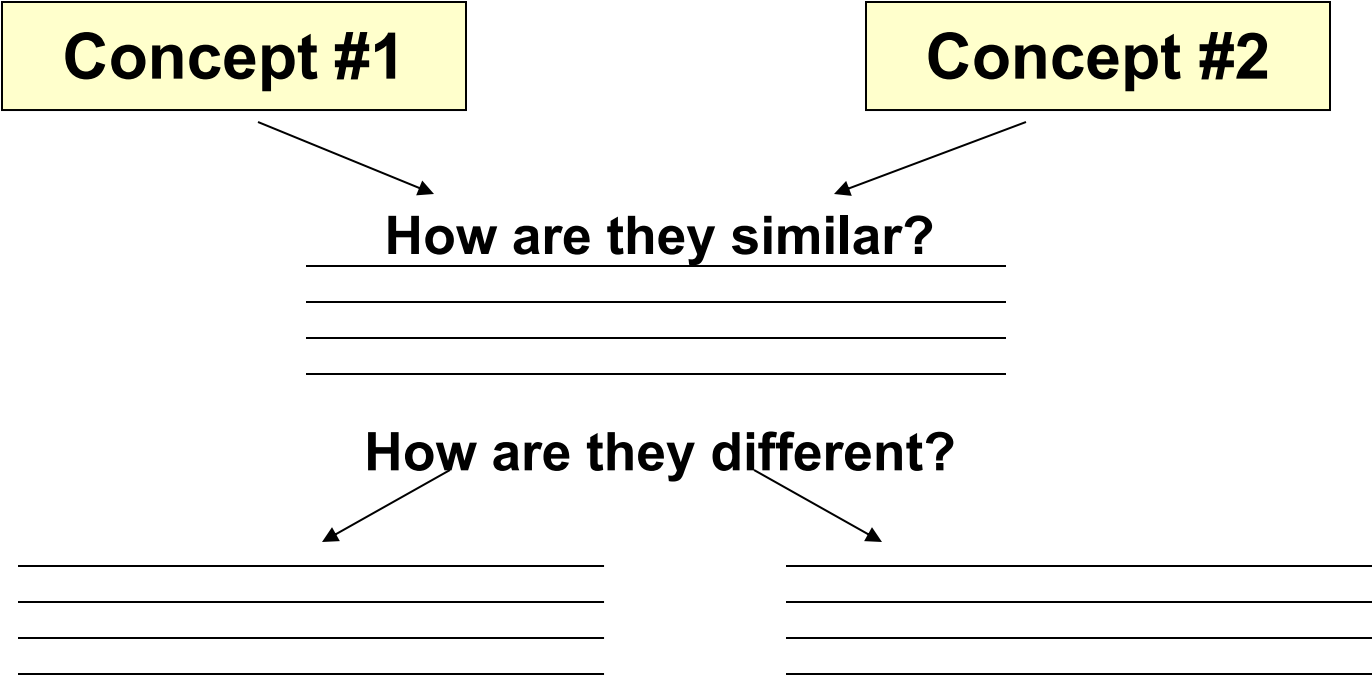
Which One of the Next Two Slides More Accurately Describes YOUR Actions Before Test 1?

Top 5 Reasons Folks Did Not Do Well on Test 1 in Chemistry 1201 in Fall 2009:

1. Didn't spend enough time on the material

2. Started the homework too late

3. Didn't memorize the information I needed to

4. Did not use the book

5. Assumed I understood information that I had read and re-read, but had not applied.

Top 5 Reasons Folks Made an A on Test 1:

1. Did preview-review for every class

2. Did a little of the homework at a time

3. Used the book and did the suggested problems

4. Made flashcards of the information to be memorized

5. Practiced explaining the information to others

Get the Most Out of Homework

1. Start the problems early--the day they are assigned

2. **Do not flip back to see example problems; work them yourself!**

3. Don't give up too soon (<15 min.)

4. Don't spend too much time (>30 min.)

Get the Most from Tutorial Centers, Office Hours, and Study Groups

- Try to understand the concept or work the problem by yourself first

- Come prepared to ask questions

- Explain the material to the tutor or instructor

Writing Exercise

What strategy will you use for the next three weeks?

If you don't try it in within the next 48 hours…

… you probably never will.

Cook *et al*. (2013): General chemistry

Mcguire led a 50 min lecture with 3 goals:

1. Explain to students why the skills that they found effective in high school no longer work at the university;
2. offer students a smorgasbord of metacognitive learning tools to replace or supplement those used in high school; and
3. secure from the students a commitment (via a short writing exercise) to use those tools in the weeks following the presentation.

For 2011:
Attendees Exam 1: 74
Non-attendees Exam 1: 68
→ Gap existed, but grew

Table 2. Final Average Course Grades in the General Chemistry I Course in the Fall 2010 and 2011

		2010		2011
Intervention Status	N	Final Average (Letter Grade)[a]	N	Final Average (Letter Grade)[a]
Attendees: treatment	428	81.5 (B)	473	81.6 (B)
Nonattendees: control	167	72.6 (C)	195	70.4 (C)

[a]A 10-point grade system was adopted: A ≥ 90% > B ≥ 80% > C ≥ 70% > D ≥ 60% > F.

Cook E, Kennedy E, and McGuire SY. "Effect of Teaching Metacognitive Learning Strategies on Performance in General Chemistry Courses." J. Chem. Educ.. 2013; 90 (8): 961–967.

Zhao *et al*. (2014): Gen chemistry

Gave an intervention upon handing back exam 1

- "Give the top 3 reasons you believe you did well or poorly on this exam."
- First slide of intervention: "The Goal: Get an A!"
- Objectives:
  - Analyze your current learning strategies
  - Distinguish between meaningful learning and rote memorization
  - Introduce concrete and effective strategies

FIGURE 1
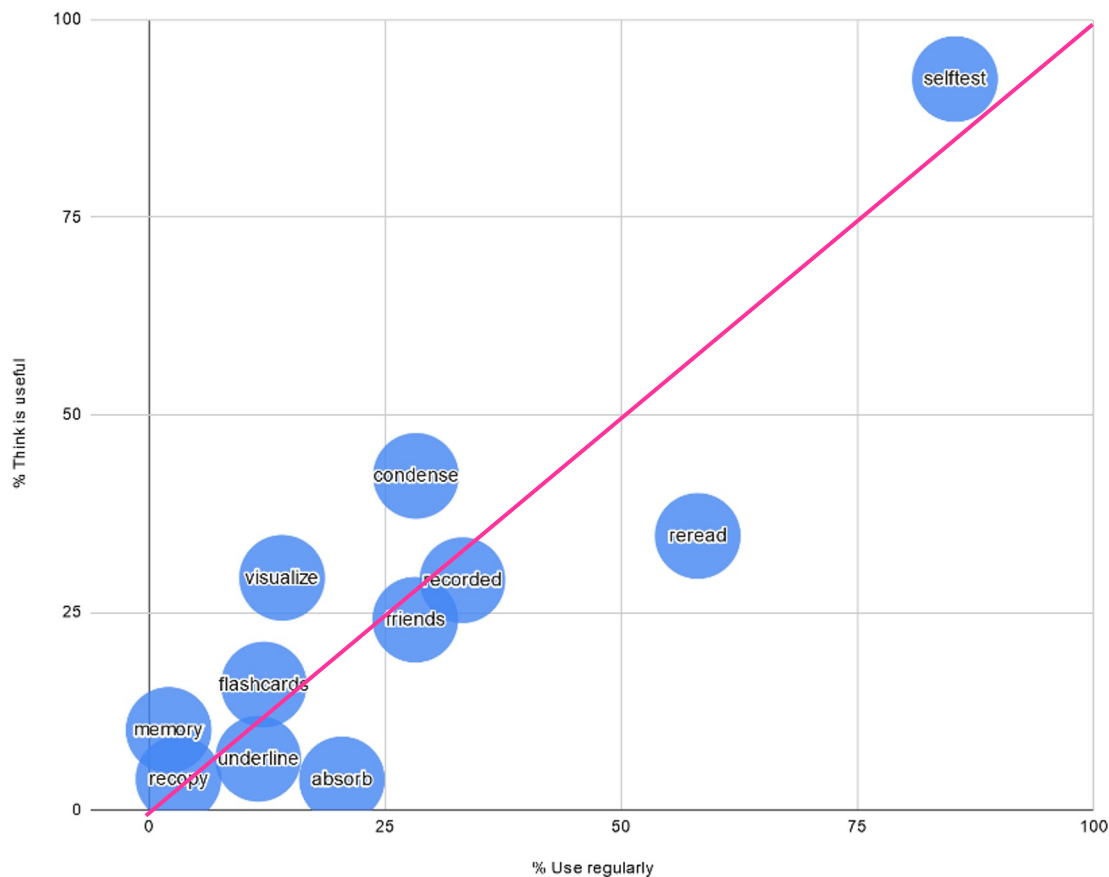
Student exam performance for the fall semesters.
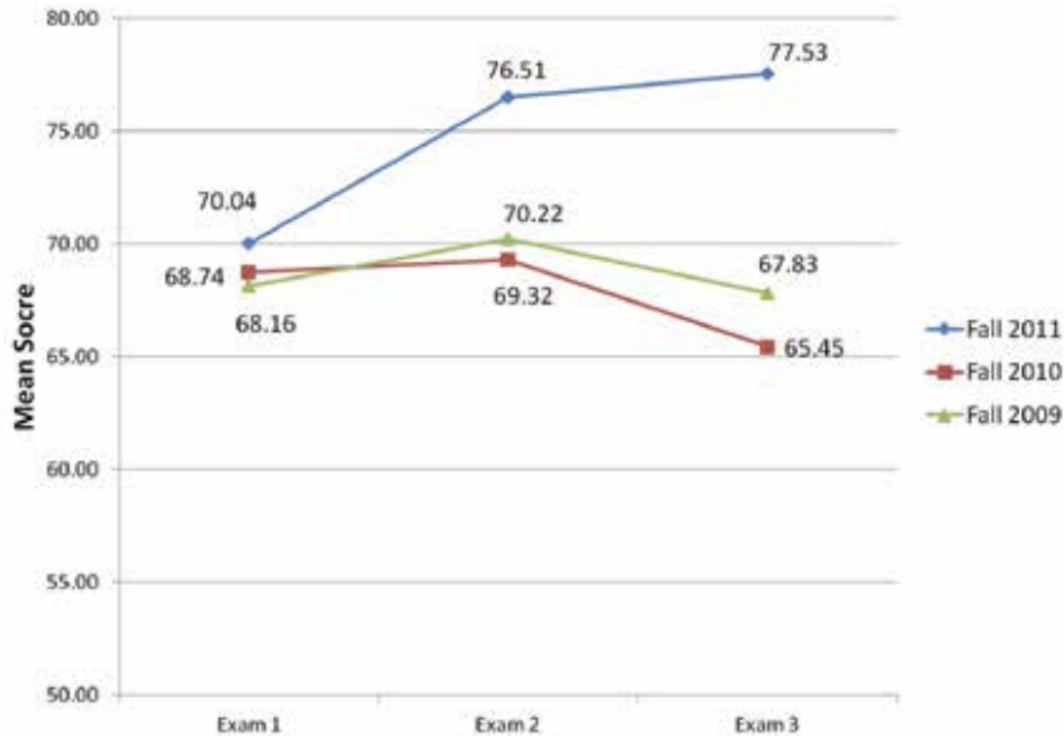
Fall 2011 was the intervention year

Fall 2009 and **2010** are negative controls

Would you be interested in developing materials to help your student succeed?

Here are some examples of what we could do here…

Student Use vs. Perception of Learning Strategies (pre-test Fall 2019)

1. Test yourself with questions or practice problems (**selftest**)

2. **Reread** chapters, articles, notes, etc.

3. Watch/listen to **recorded** lessons either by instructor or from outside source

4. **Condensing**/summarizing your notes

5. Study with **friends**

6. **Absorb** lots of information the night before the test

7. Make diagrams, charts or pictures (**visualize**)

8. Use **flashcards**

9. **Underlining** or highlighting while reading

10. **Recopy** your notes word-for-word

11. Recopy your notes from **memory**

Student Use vs. Perception of Learning Strategies (pre-test Fall 2019)
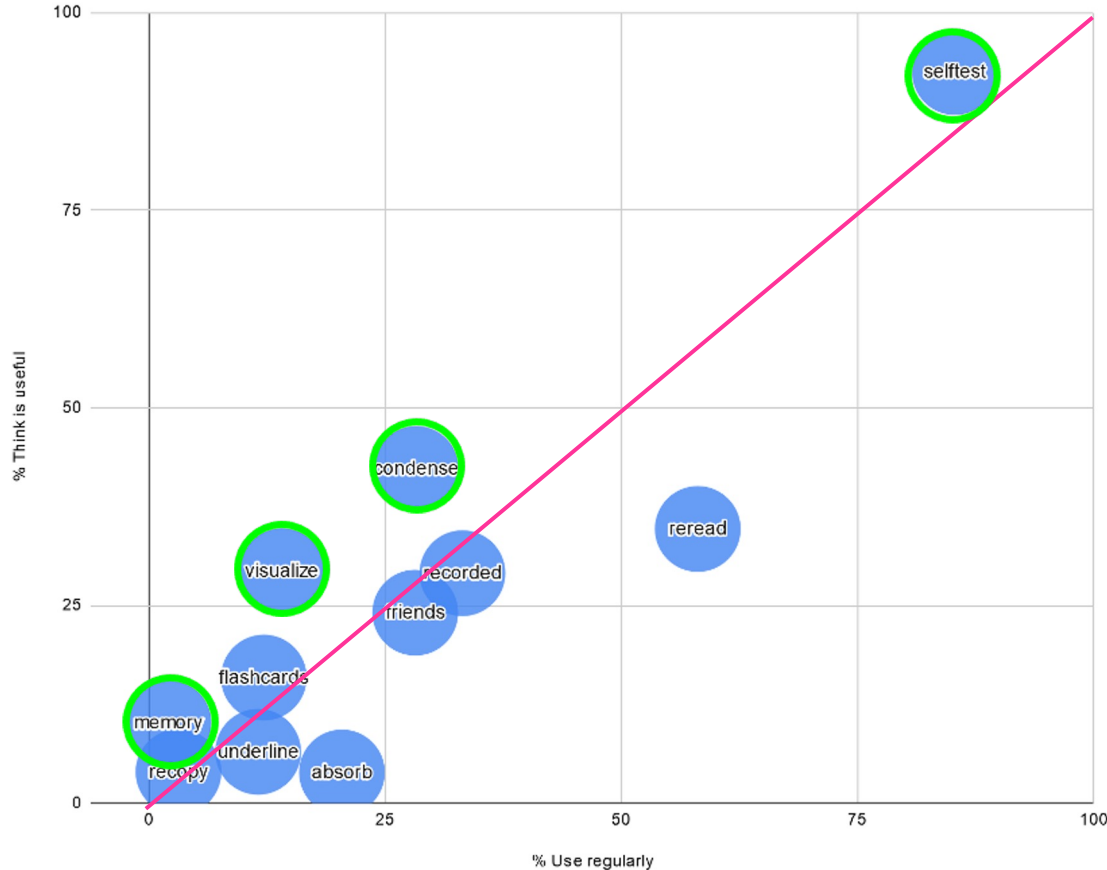
Effective Strategies

Self-Test:
Test yourself with questions or practice problems
(Rodriguez, 2018)

Condense:
Condensing/summarizing your notes
(Rodriguez, 2018)

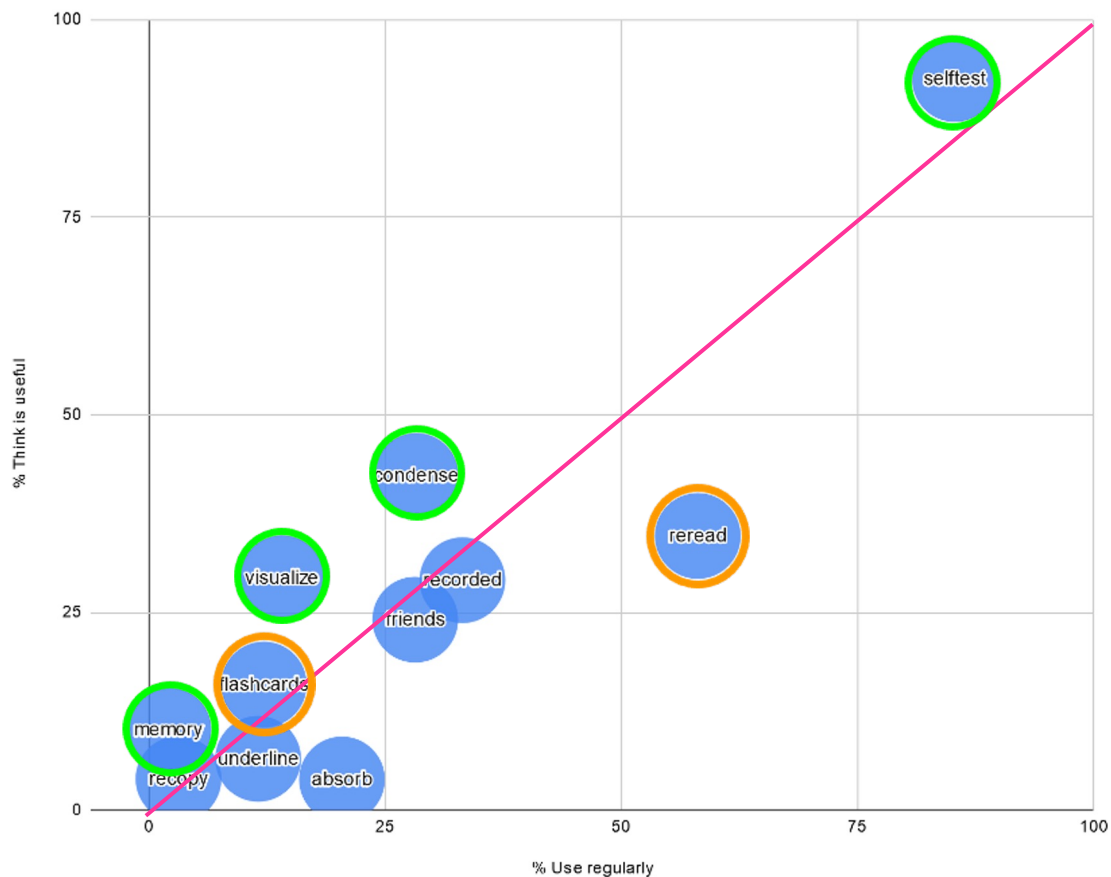**Visualize:**
Make diagrams, charts or pictures
(Rodriguez 2018)

Memory:
Recopy your notes from memory
(Karpicke & Blunt, 2011)

Student Use vs. Perception of Learning Strategies (pre-test Fall 2019)
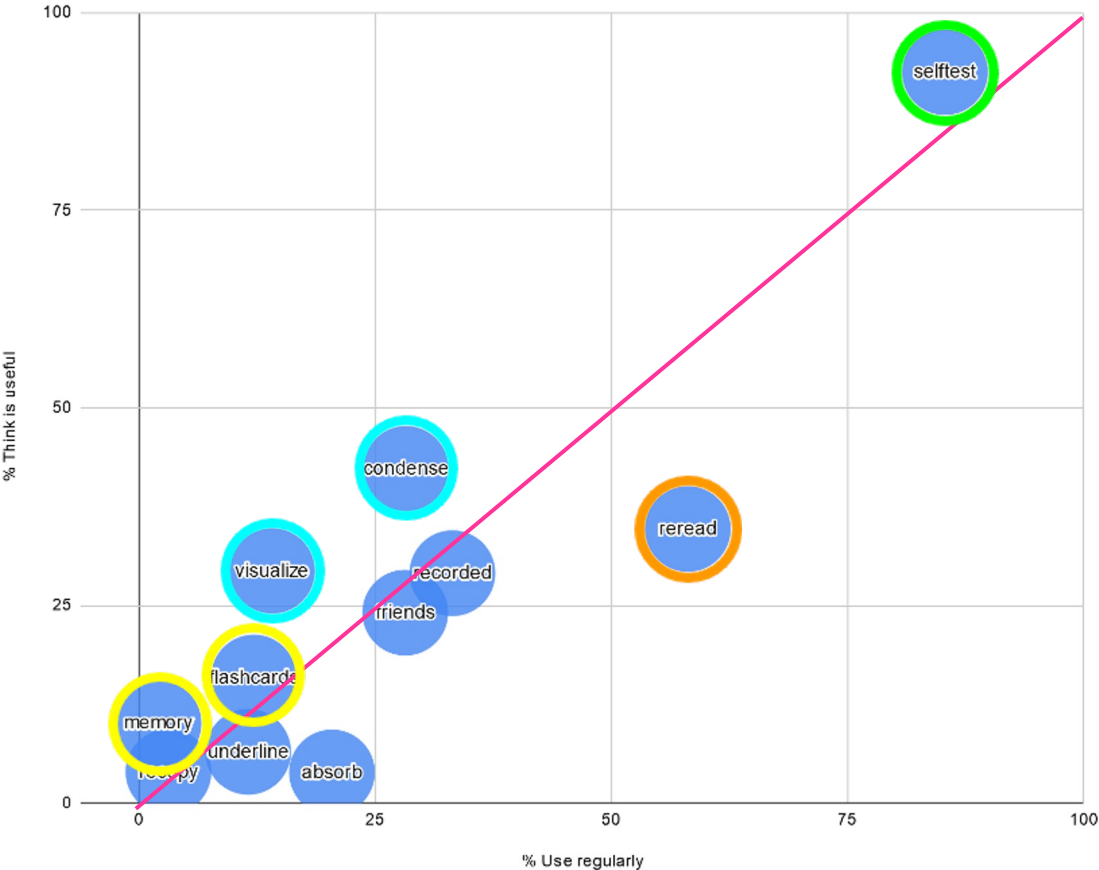
Ineffective Strategies
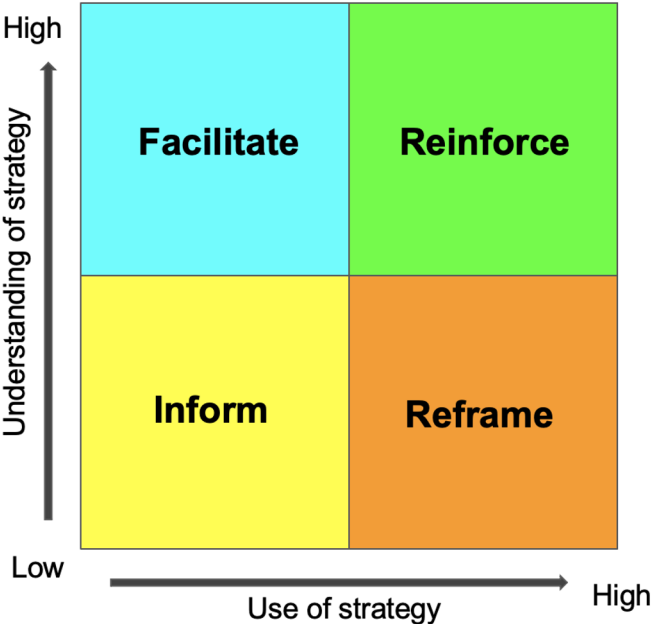
Flashcards:
Use flashcards
(Rodriguez, 2018)

Reread:
Reread chapters, articles, notes etc.
(Rodriguez, 2018)

Student Use vs. Perception of Learning Strategies (pre-test Fall 2019)

From analysis to action

Possible Interventions

1. **Reinforce:** How can you make practice tests work best for you?
(Demonstrate how much more effective self-testing is than rereading, and how to self-test effectively.)

2. **Reframe** & **Facilitate**: While re-reading your notes, you should condense material and make sense of it by creating diagrams, charts, and pictures
(Nudge students towards learning practices with higher cognitive demand)

3. **Inform:** Flashcards can be an effective study aid if you are using them in a way that promotes interleaving or retrieval practices.
(Define, give examples, and evidence for effectiveness)

Develop in-class activities

1. How to study using a practice exam

Jamie and Alex are two students studying for an exam, using the blank practice exam and answer key provided by the course. Both Jamie and Alex give themselves only 90 minutes to complete the blank practice exam, as recommended by their instructors and TFs. However, whereas Jamie looks at the answer key for confirmation after each question while taking the practice exam, Alex does all the questions on the practice exam in 90 minutes without looking at the answer key until the 90 minutes are over (as shown below).
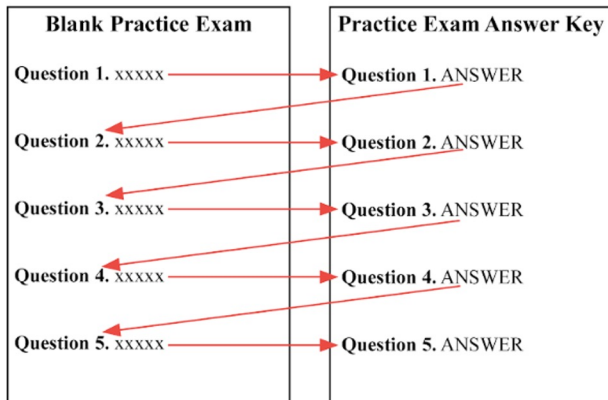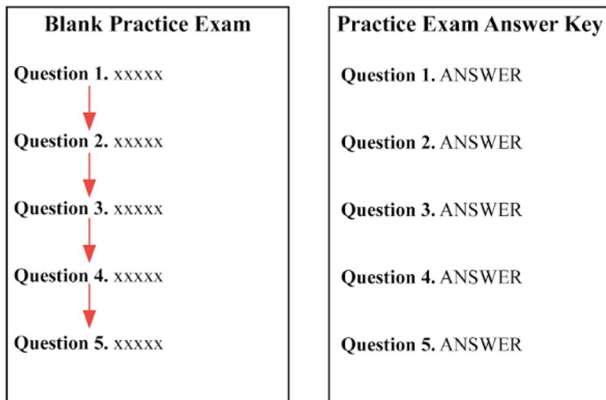
Do you think Jamie or Alex is studying more effectively for their exam? Briefly explain your reasoning.

2. Self-testing vs rereading in-class activity

A. In the first experiment, students were divided into two groups:
- Group 1 got to read the material twice ("Study, Study")
- Group 2 got to read the material once and then tested themselves on it ("Study, Test")

How did the two groups differ in the retention of the material two days later? A week later?

B. In a follow up experiment, they compared students who:

- Read material, and then re-read it 3 more times ("SSSS" condition)
- Read the material, then re-read it 2 more times, then tested themselves ("SSST" condition)
- Read the material once, then tested themselves over and over and over again ("STTT")

Which student group learned the material most deeply?

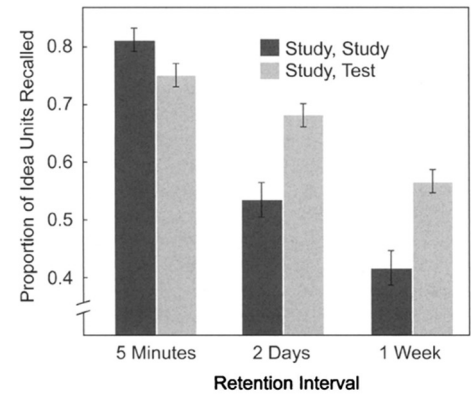**How will this impact how you study for your next exam?**

Fig. 6. Mean proportion of idea units recalled from a prose passage after a 5-min, 2-day, or 1-week retention interval as a function of whether subjects studied the passages twice or studied them once before taking an initial test. Error bars represent standard errors of the means. From Roediger and Karpicke (2006).
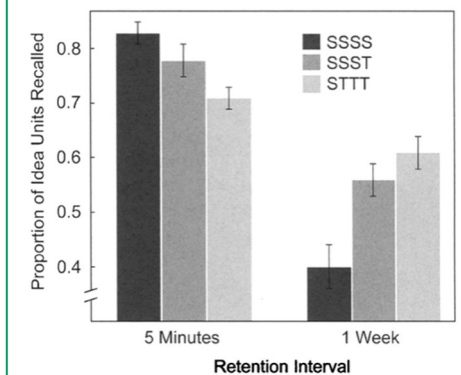

Fig. 7. Mean proportion of idea units recalled on a final test 5 min or 1 week after learning as a function of learning condition. The shorthand condition labels indicate the order of study (S) and test (T) periods. Error bars represent standard errors of the means. From Roediger and Karpicke (2006).

2. Self-testing vs rereading TA-led activity

Front

Subjects 80 undergraduates.

Learning Material A prose passage (275 words in length) on a single scientific topic ("Sea Otters") with 30 idea units/concepts.

Learning process S or T represents 7-min of time, D is 2-min of a distractor task.

Group1: S **S**tudy the passage for the first and only time

Group 2: S - D - S - D - S - D - S
Study the passage for the first time, then re**s**tudy three more times.

Group 3: S - D - T - D - S - D - T
Study the passage for the first time, take a **t**est, then re**s**tudy, and take another **t**est.
The tests are **free-recall tests** (write down on a blank sheet as much of the material from the passage as they could remember).

After 1 week, students are tested with questions on the passage, some of which assess conceptual knowledge stated directly in the text and others require students to connect multiple concepts from the text. **Which student group do you think retained the material better after 1 week?**

Back

Correct %	S	S-S-S-S	S-T-S-T
prediction	~68	~80	~58
14 Verbatim Questions - assess conceptual knowledge stated directly in the text	28 ± 2	46 ± 3	68 ± 2
2 Inference questions - require students to connect multiple concepts from the text	28 ± 5	57 ± 5	68 ± 2

TF note: We'll do a warm-up activity and discuss best learning practices we recommend in PS11.
1. Why we do this activity? To be **transparent** about the learning practices we recommend. This is based on educational research, and also confirmed by past PS11 students' experience.
2. Let's first look at an educational experiment reported in the journal of Science in 2011.
   - **do not look** at the back yet
   - read and answer the question at the bottom, and we will have anonymous vote after this.
   - have them close their eyes and vote
   - reveal the result at the back, discuss in large group why Group 3 retain material better.
   Take away: They get to identify the areas that they do not know, and the follow-up study is more targeted.
   i.e. check to know what you do not know, and get help to learn those.
3. Pair and share: how to apply this to PS11? (Give the 2nd handout out , ask them to wait & look at it together late

Student handout: front side
Ref: *Science* 11 Feb 2011:Vol. 331, Issue 6018, pp. 772-775, DOI: 10.1126/science.1199327

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Group 3: S - D - T - D - S - D - T
Study the passage for the first time, take a **t**est, then re**s**tudy, and take another **t**est.
The tests are **free-recall tests** (write down on a blank sheet as much of the material from the passage as they could remember).

After 1 week, students are tested with questions on the passage, some of which assess conceptual knowledge stated directly in the text and others require students to connect multiple concepts from the text. **Which student group do you think retained the material better after 1 week?**

Student handout: back side highlight in the result: Group 2 and 3 spent **same amount of time**, but Group 3 do significantly better.

Correct %	S	S-S-S-S	S-T-S-T
prediction	~68	~80	~58
14 Verbatim Questions - assess conceptual knowledge stated directly in the text	28 ± 2	46 ± 3	68 ± 2
2 Inference questions - require students to connect multiple concepts from the text	28 ± 5	57 ± 5	68 ± 2

Student interviews
Narratives about how they study, and how they learned how to study

20191028_001_Learning…
Learning Lab

20191025_001_Learning…
Learning Lab

20191023_001_Learning…
Learning Lab

20191108_006_Learning…
Learning Lab

20191108_005_Learning…
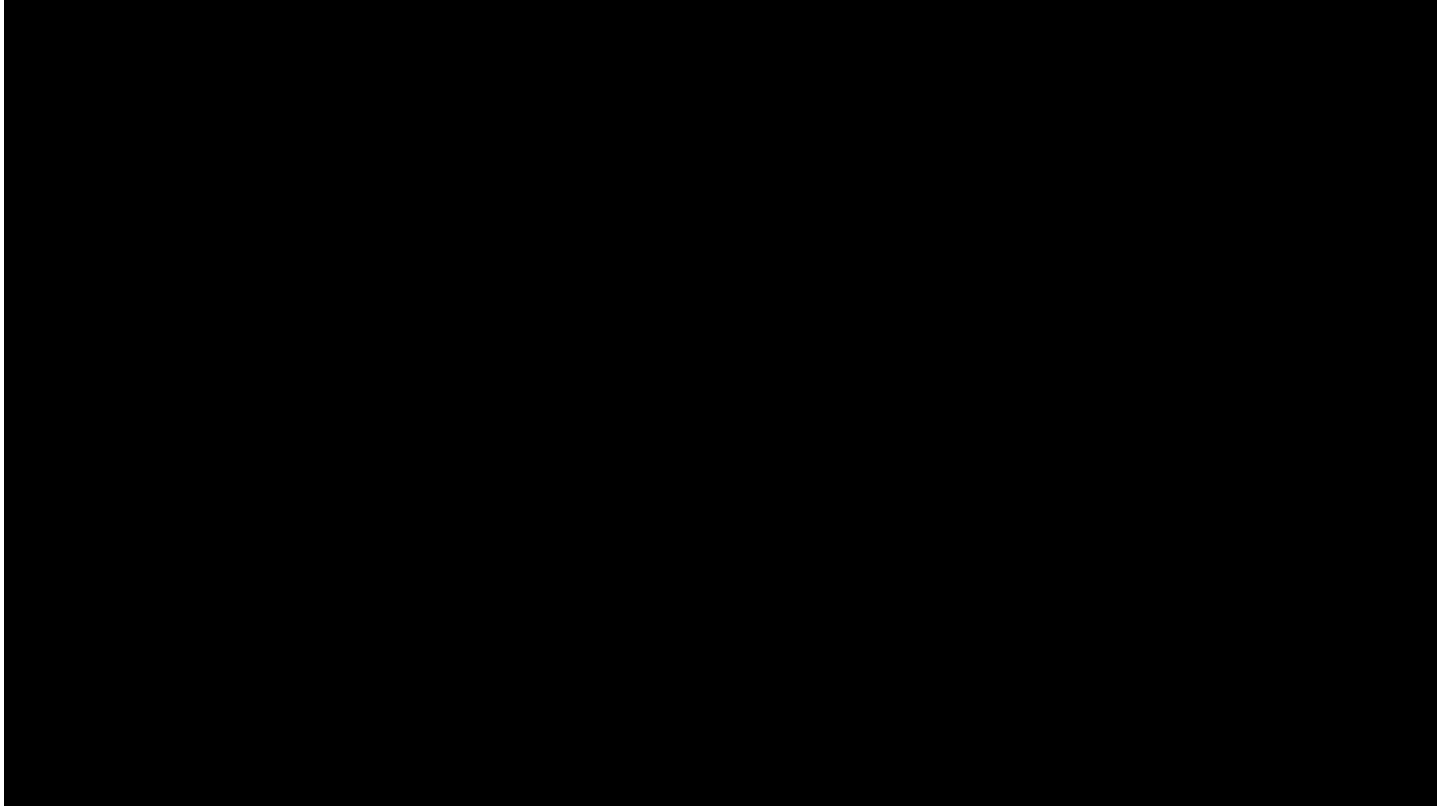Learning Lab

20191107_001_Learning…

Student interviews

Narratives about how they study, and how they learned how to study, for example:

Summary

- Effective study strategies include
  - Self test ("retrieval practice")
  - Condense
  - Visualize
  - Memory
  - Spacing and interleaving
  - Promoting "metacognitive" awareness of student's own strengths and areas for improvement
- Less effective study strategies (potentially even negative)
  - Rereading/rewatching
  - Flashcards (can be improved by emphasizing interleaving)
- Study cycle
  - Emphasizes targeted, spaced learning
  - Motivated by early opportunity to struggle in class and by teaching Bloom's taxonomy
- Share with your students how you want them to study
  - Design in-class or homework assignments or study guides that teach how to study (not just what to study)