

Some novel techniques for enhancing student learning

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Student written examinations

Handing over the classroom



Motivation

- Examinations widely considered solely an evaluation tool, not learning tool
- Students often have trouble directing their studying efforts
- Evidence exists that “turning over the classroom” results in enhanced learning
 - Students take ownership
- I’m lazy



Assigned as final HW...

- Students write 6-10 final exam questions
- Must cover at least 6 topics
- Must include 4 or 5 possible answers
- I post all questions and answers online prior to exam

CVEN 306

HW 10

Due Monday, April 30 at 5pm at Aishwarya's office

HW is worth 20 points... you get full credit if you write at least 6 questions

You must follow directions below in their entirety to receive credit for this HW!

You may work in groups of two!

The objective of this final homework of the semester is for YOU THE STUDENTS to write your own final examination. The final exam will consist of 50-60 multiple choice questions which you have written – unless there are not 50 good questions submitted, at which point I will try to write the most difficult exam I have ever given!

- Each group of two students must write at least SIX (but as many as TEN) multiple choice questions with at least FOUR possible answers for each question. The questions must be submitted both electronically (emailed to zgrasley@civil.tamu.edu) and hard copy. **You must use the template file posted on cenotes – just enter your names into the header of the first page and replace the questions and answers with your own. Do not mark the correct answer on your electronic copy. DO NOT CHANGE THE FORMATTING!** After finishing and emailing the electronic copy, you must modify the document prior to printing off a copy to hand in. **Insert a page break before each question so that there is one question (with answers) per page. Print only ONE side (not double-sided). Circle the correct answers on the printed hardcopy.**
- For your six questions, you must cover at least six of the following topics (i.e. each question must address a different topic, although some questions may link multiple topics):
 1. Atomic structure and bonding
 2. Crystal structure, polymer structure, ceramic structure
 3. Defects
 4. Elasticity, plasticity
 5. Viscoelasticity (creep and creep failure), brittle behavior

Quality assurance



- I choose top 50-60 questions of those submitted
 - 2 EC points added to final exam score for each question chosen
- I write conceptual questions for first two exams
 - Students expect me to choose conceptual and/or challenging questions

Example questions

- Which of the following is **not** a way to prevent or slow corrosion of steel?
 - Reduce the temperature of the system
 - Attach a more anodic material to the materials that needs to be protected
 - Apply a voltage to move the material to the immune region on the Pourbaix Diagram
 - Supersaturate the surrounding area with oxygen so the reaction is smothered

- Suppose we have a 2 mm long cylindrical steel of bar between two rigid walls. The cylinder is attached to one wall and there is a small gap of .01 mm between the cylinder and the second wall. If the initial temperature is of 0 Kelvin and it is raised to 500 Kelvin, what will be the final stress on the bar? ($E=200$ GPA, $\alpha = 12 \times 10^{-6}$ /K)
 - 0 The bar will never reach the second wall
 - -2×10^8 Pa
 - 1.2×10^9 Pa
 - 2×10^8 Pa
 - -1.2×10^9 Pa



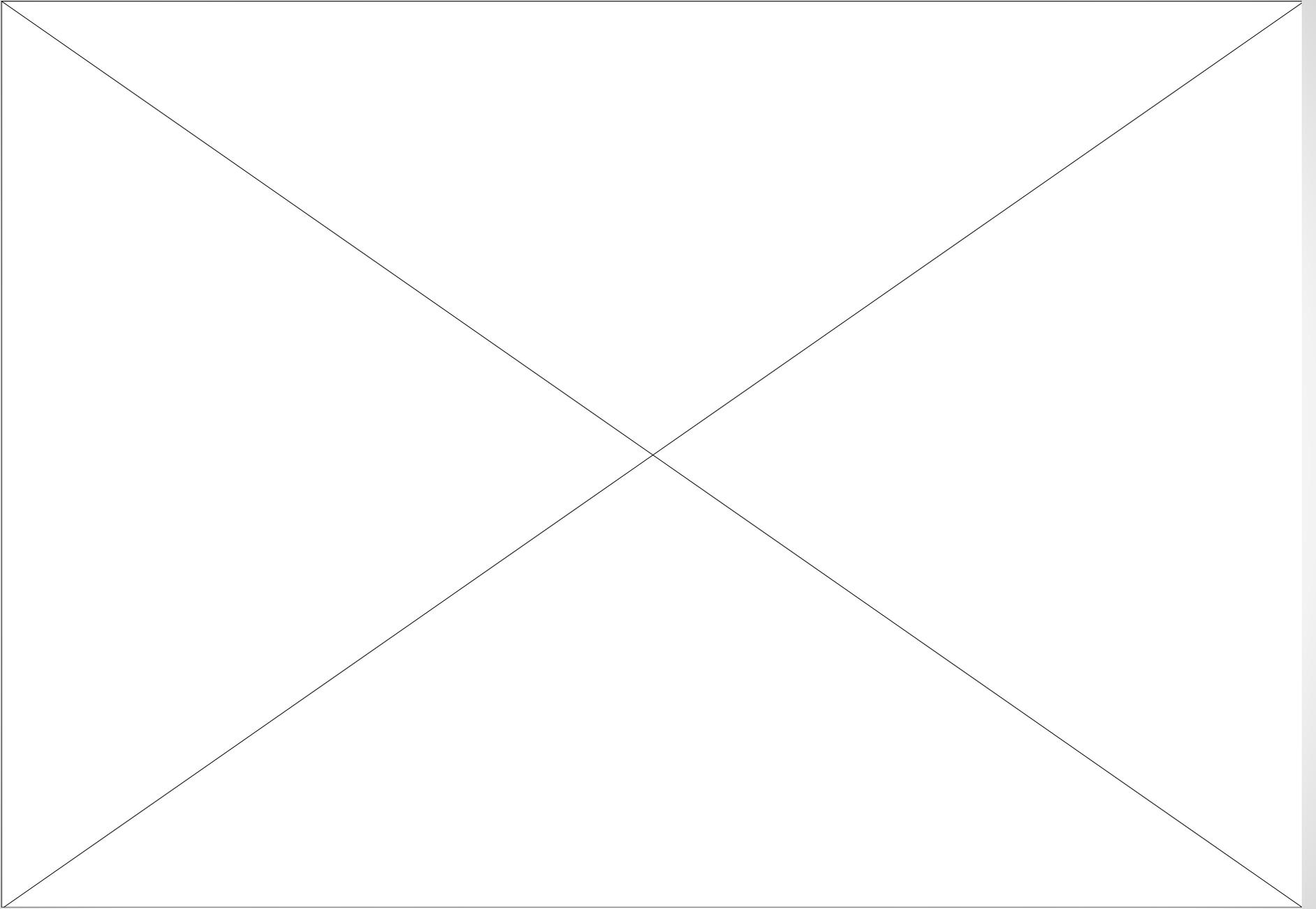
Benefits

- Students believe I like “hard” questions
- → Self-direct themselves to material they found challenging
- → Learn the challenging material in order to write a good question (and answers!)
- Developing plausible “wrong” answers requires true understanding of the material!
- More focused studying
- Feedback tells me students spend more time studying for exams they write

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Cell phone polling

Keeping them active and alert...



Cell phones in class?

- The attention span of our typical students may be as little as 15 minutes!
 - Typical lectures = 50 minutes plus
- Polls can be used to pique interest or to provoke thought on new topic



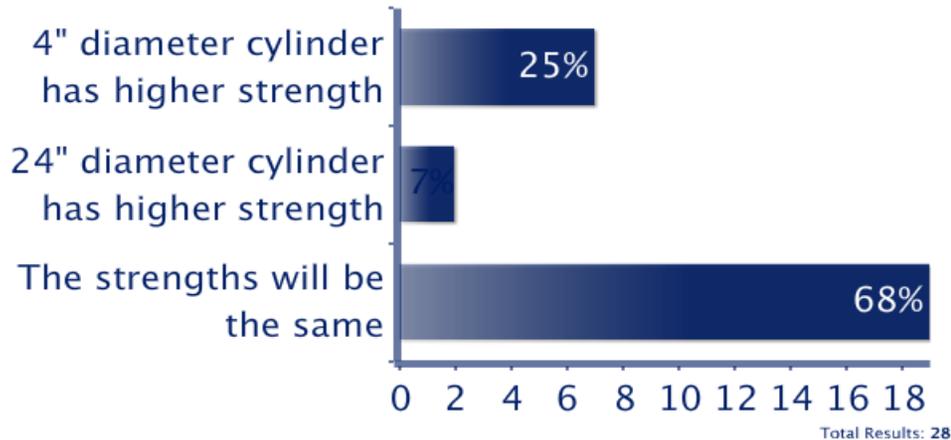
Cartoon courtesy of <http://www.philosophyoffreedom.com/>

- Wankat and Oreovicz, "Teaching: Breaking the 15 Minute Barrier", ASEE Prism, V 12 n 8 (2003).

Example questions

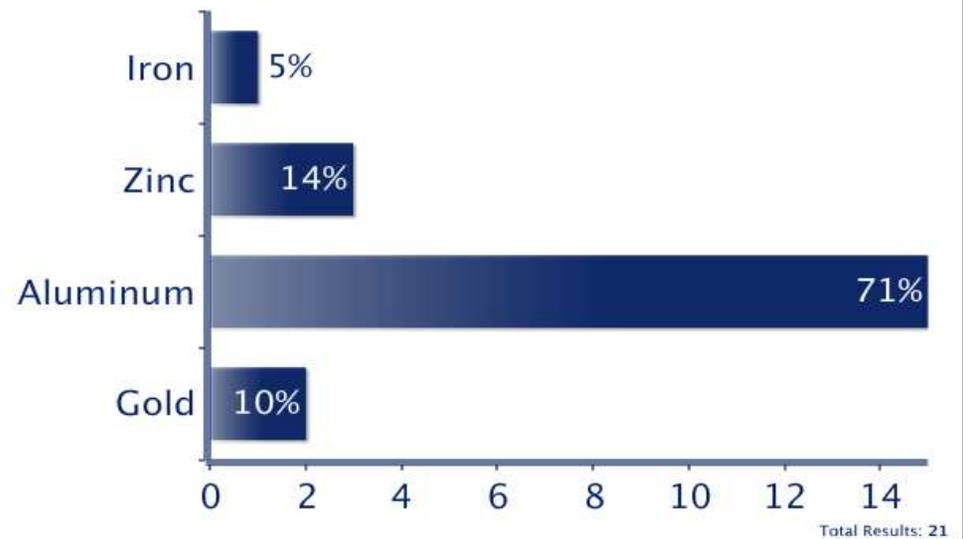
Which has a higher ultimate strength? A 4" diameter concrete cylinder or a 24" diameter concrete cylinder?

 **Start** this poll to accept responses



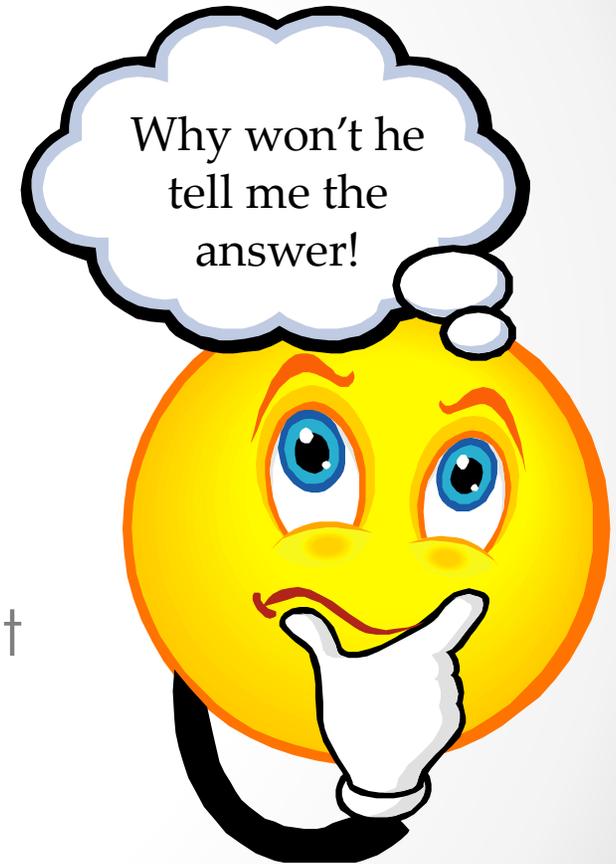
Which material is most likely to corrode away?

 **Start** this poll to accept responses



Benefits

- Provocative questions make students pay attention following the poll
- Re-energizes the class, loosens them up for follow-up Q&A
- A means for simply quantifying class participation at the end of the semester
- No physical infrastructure requirement like “clickers”
 - Every student has a cell phone!



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Tablet PC

Combining chalk-talk and PowerPoint



Motivation

- PowerPoint has benefits
 - Video
 - Complex graphics, data
 - Clear, legible
- PowerPoint has problems
 - Encourages passive students
 - Does not moderate pace effectively
 - Overload of information
- Chalk-talk has benefits
 - Controls pace
 - Encourages students to follow along and participate
- Chalk-talk has problems
 - Limited ability to show complex graphics, data, and video
 - Legibility problems?



Methodology

- Create a PowerPoint lecture
- Leave off pertinent information
- Distribute PowerPoint lecture prior to class
- Hand-write pertinent information on slides during lecture
 - Solve example problems
 - Highlight important features
 - Answer class questions
- Hand-writing is typically linked to learning objectives

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Example lecture slide

Porosity extremely important

- Increased pore volume →
 - lower strength
 - higher permeability
 - higher shrinkage
- Increase average pore size →
 - higher permeability

Types of "void space" in concrete

entrapped
entrained
capillary
gel

- poor consolidation

- purposefully distributed spherical bubbles

- micrometer – mm sized voids from extra mix water

- nanometer sized voids inherent to the C-S-H structure

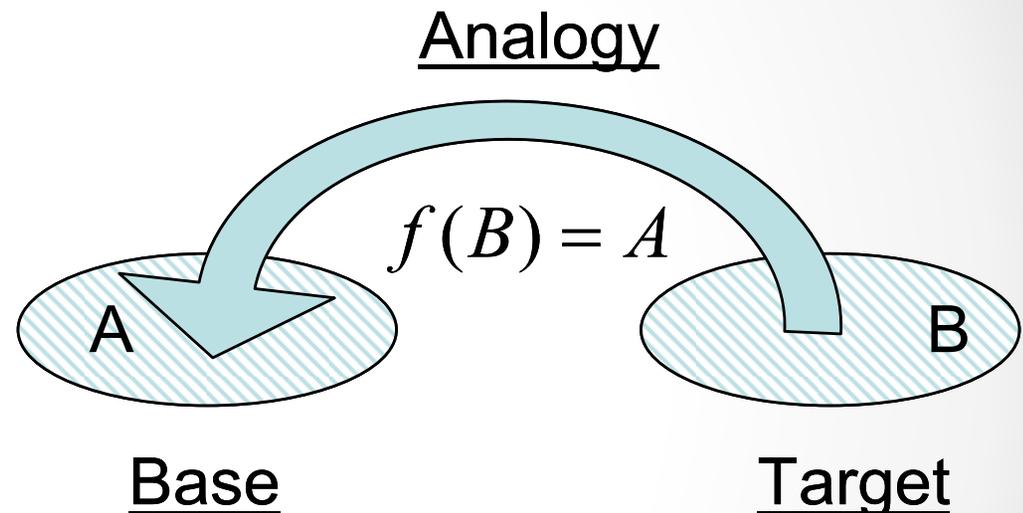
Student-derived analogies

What drives true understanding?



Motivation

- Studies on learning suggest new understanding comes from linking new info to current framework of understanding in analogical ways
- Analogies long used by successful teachers
- Having students derive analogies helps assure target is tied to THEIR base



*With many similar parables Jesus spoke the word to them, as much as they could understand. He did not say anything to them without using a parable.
Mark 4:33-34*

Methodology

- Step 1: Develop concept inventory (CI) exam for quantifying conceptual understanding
- Step 2: Administer CI exam at beginning (pre-test) and end (post-test) of semester to develop baseline of conceptual improvement when student-derived analogies are not used
- Step 3: Implement innovation by having students develop (and rank) analogies throughout semester. Again administer CI exam pre-test and post-test to evaluate conceptual improvement
- Step 4: Compare semesters with/without student-derived analogies

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Developing analogies

- Problem on each HW assignment
- Work in small groups
- Develop analogy addressing current lecture topic
- Example analogies would be given to help students identify appropriate target and base
- Analogies posted to Facebook-like forum
- Students rank analogies posted by their peers

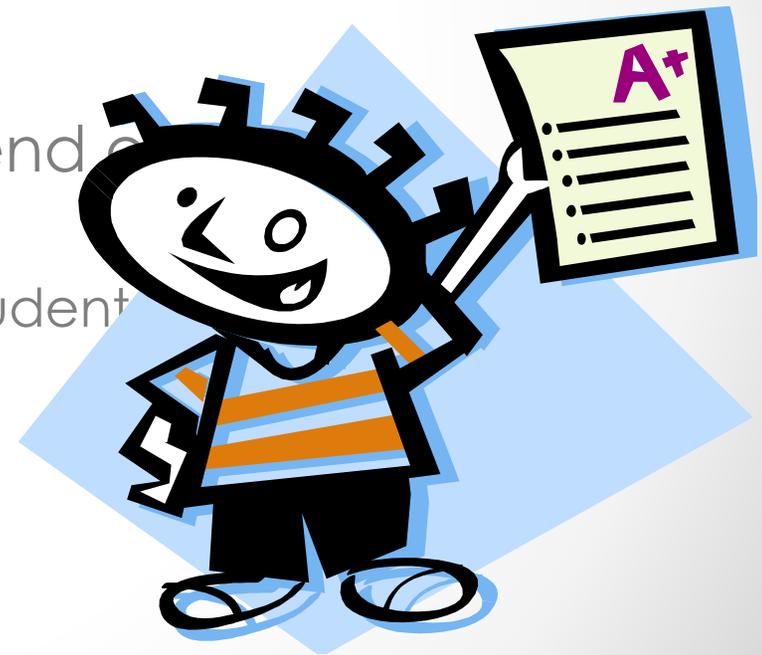
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Example analogy

Atomic bond strength versus distance is like the relationship between a boyfriend and girlfriend. If you get too close, your boyfriend or girlfriend might push you away, but if you get too far away, they will want to draw you back to them.

Evaluating student learning

- Goal: students to improve understanding of abstract concepts
- “Concept Inventory” (CI) exams test students’ understanding of various, relevant abstract concepts
- Administer tests at beginning and end of semester
 - Track improvement as a measure of student learning

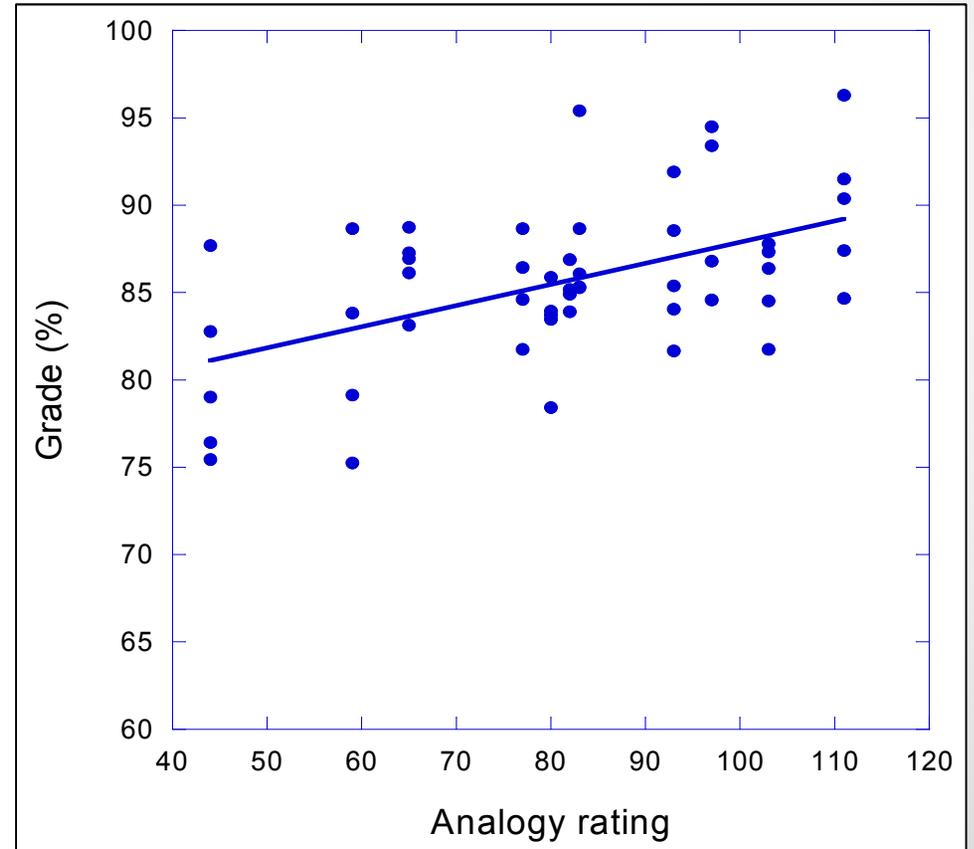
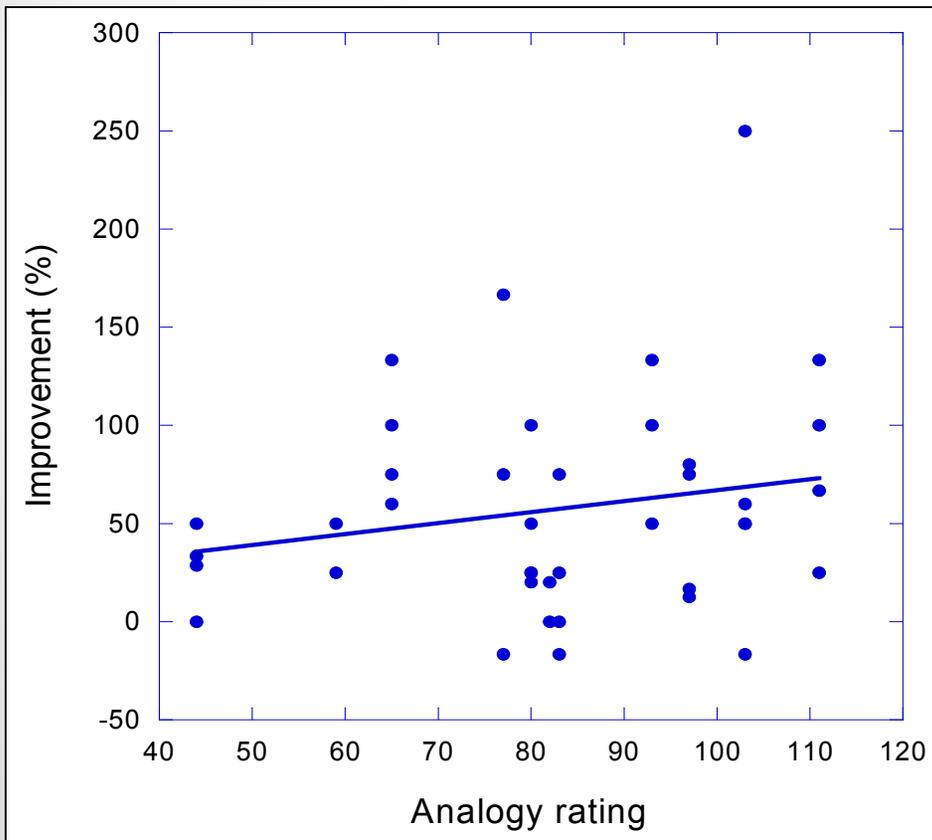


Example CI question

Dr. Grasley has a booth in his kitchen. The seat is made of maple, but the counter is made from granite. If you put one hand on the seat and one hand on the counter, the seat feels warmer. Why?

- a. atoms are more tightly bonded in the maple than in the granite
- b. The wood is warmer (a higher temperature) than the granite
- c. granite has higher thermal conductivity than wood
- d. the granite has a lower heat capacity than wood

Quality of analogies matters



Outcome

- Students that derive high quality analogies improve their CI scores more than their peers
 - Also achieve higher final grades in the class
- The primary challenge is to find ways to help students derive appropriate analogies
 - Evidence in the literature that developing poor analogies can actually reinforce misconceptions



Summary

- A few novel teaching techniques have been presented
 - Student-written exams
 - In-class cell phone polling
 - Use of tablet-PC
 - Student-derived analogies
- Concept inventory (CI) exams presented as means to quantify student learning
- Easy to implement
- Has led to documented improvement in student learning
- Fun to implement!

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