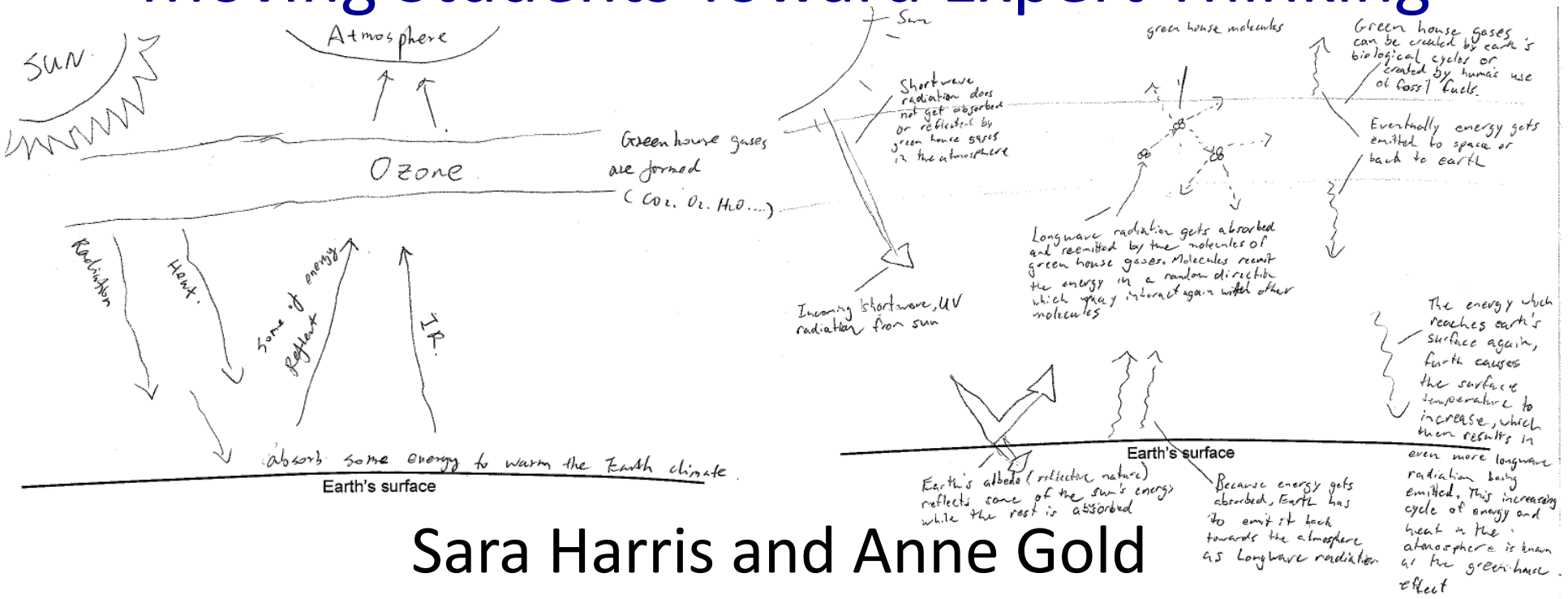
These two sets of slides are from two conference presentations

Harris, Sara and Anne Gold, 2013. *University students' mental models of the greenhouse effect: a comparison of two learning activities in moving students toward expert thinking*, Geological Society of America Meeting, Denver.

Harris, Sara and Anne Gold, 2013. *Student Mental Models of the Greenhouse Effect: Retention Months After Interventions*, American Geophysical Union Fall Meeting, San Francisco.

University Students' Mental Models of the Greenhouse Effect:

A Comparison of Two Learning Activities in Moving Students Toward Expert Thinking



Sara Harris and Anne Gold

a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA

CIRES
Cooperative Institute for Research in Environmental Sciences

The setting & participants

- Large research university
- Intro course: “Atmospheres and Oceans”
- Open to all: wide diversity of backgrounds
- Enrollment = 248
- 164 students wrote all the assessments (4)

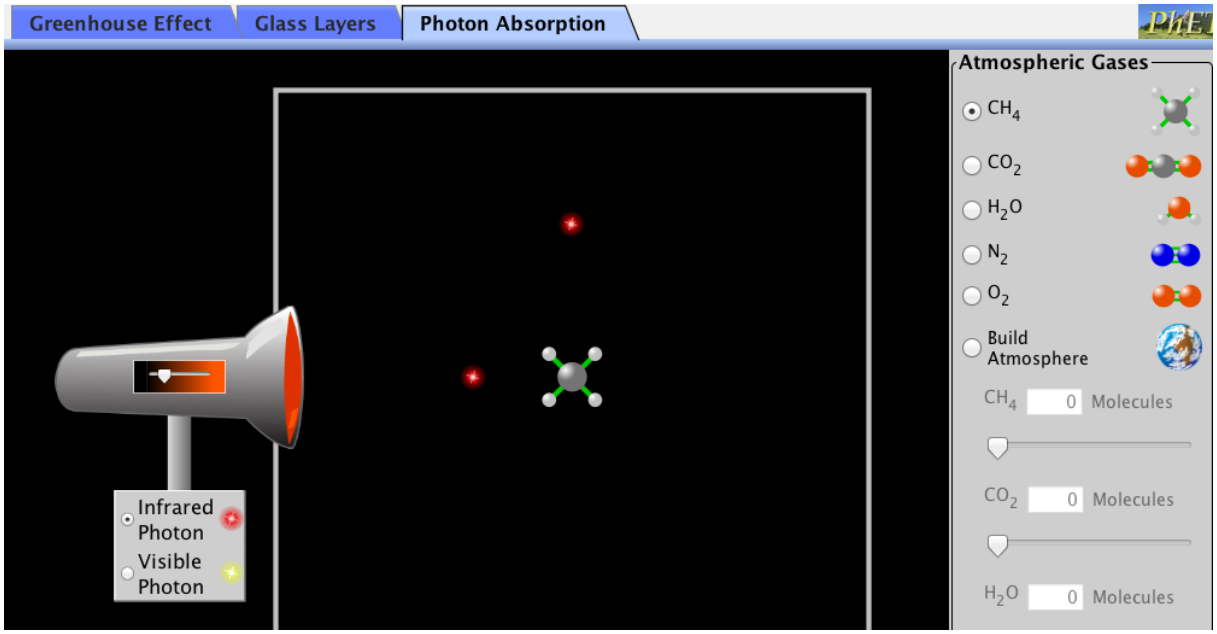
Learning Goals

(Aligned with Lessons, aligned with Assessments)

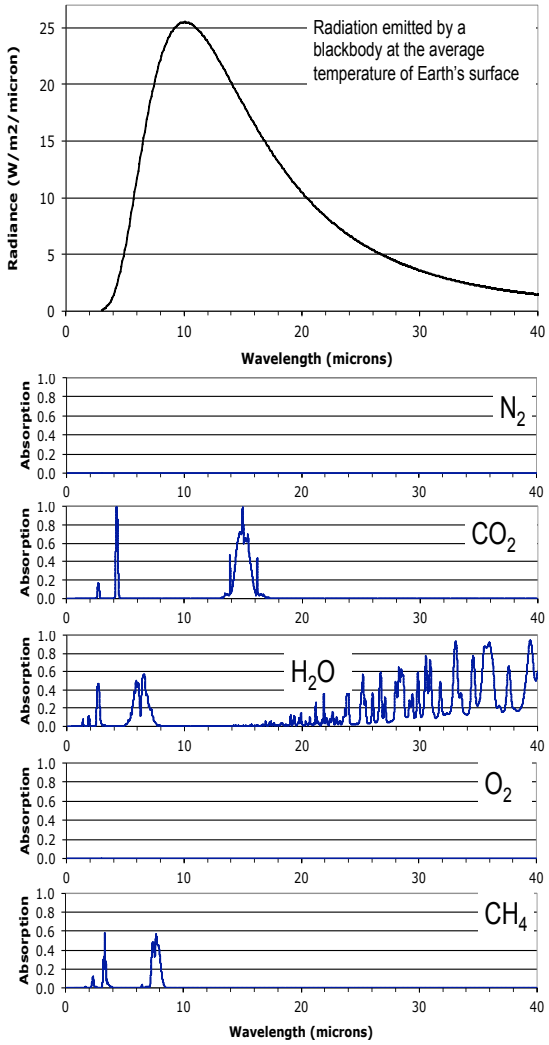
1. Identify greenhouse gases; identify non-greenhouse-gas air molecules
2. Differentiate between short wave radiation from the Sun and long wave radiation from the Earth
3. Contrast the molecular structure of greenhouse gases versus non-greenhouse gases (common air molecules)
4. Explain how the greenhouse effect warms Earth in terms of the physical processes that happen.
5. Describe how greenhouse gases themselves absorb and emit radiation, including what kinds of radiation (shortwave or longwave).
6. Describe how greenhouse gases influence flows of energy within the atmosphere, to and from Earth's surface, and to and from space.

1 Common lesson + 2 Contrasting Lessons

1. PhET Interactive Simulation (Greenhouse effect)



2. "Data" lesson (Absorption Spectra)



Assessments

PART 1: Concept Sketch* (4 times (5 including retention))

"Sketch, label, and describe how the greenhouse effect works. Identify the key features you decide to include. Explain the processes that happen. Indicate how the features and processes are related. Use clear, complete sentences and leaders."

PART 2: Short Answer and Multiple Choice

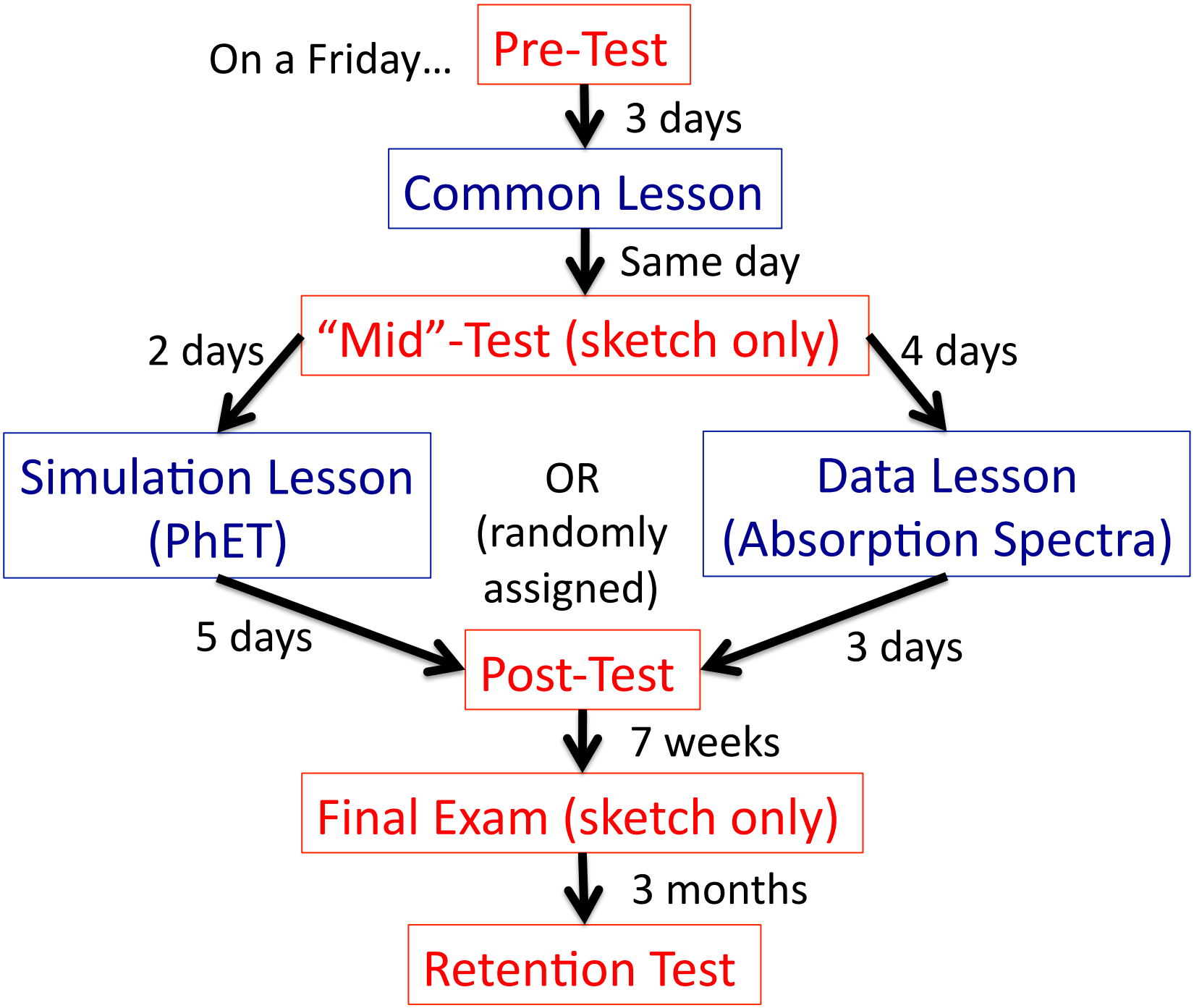
(2 times (3 including retention))

3 Short Answer questions

9 Multiple Choice questions

Questions developed and modified from existing questions. Validated with student interviews and expert review.

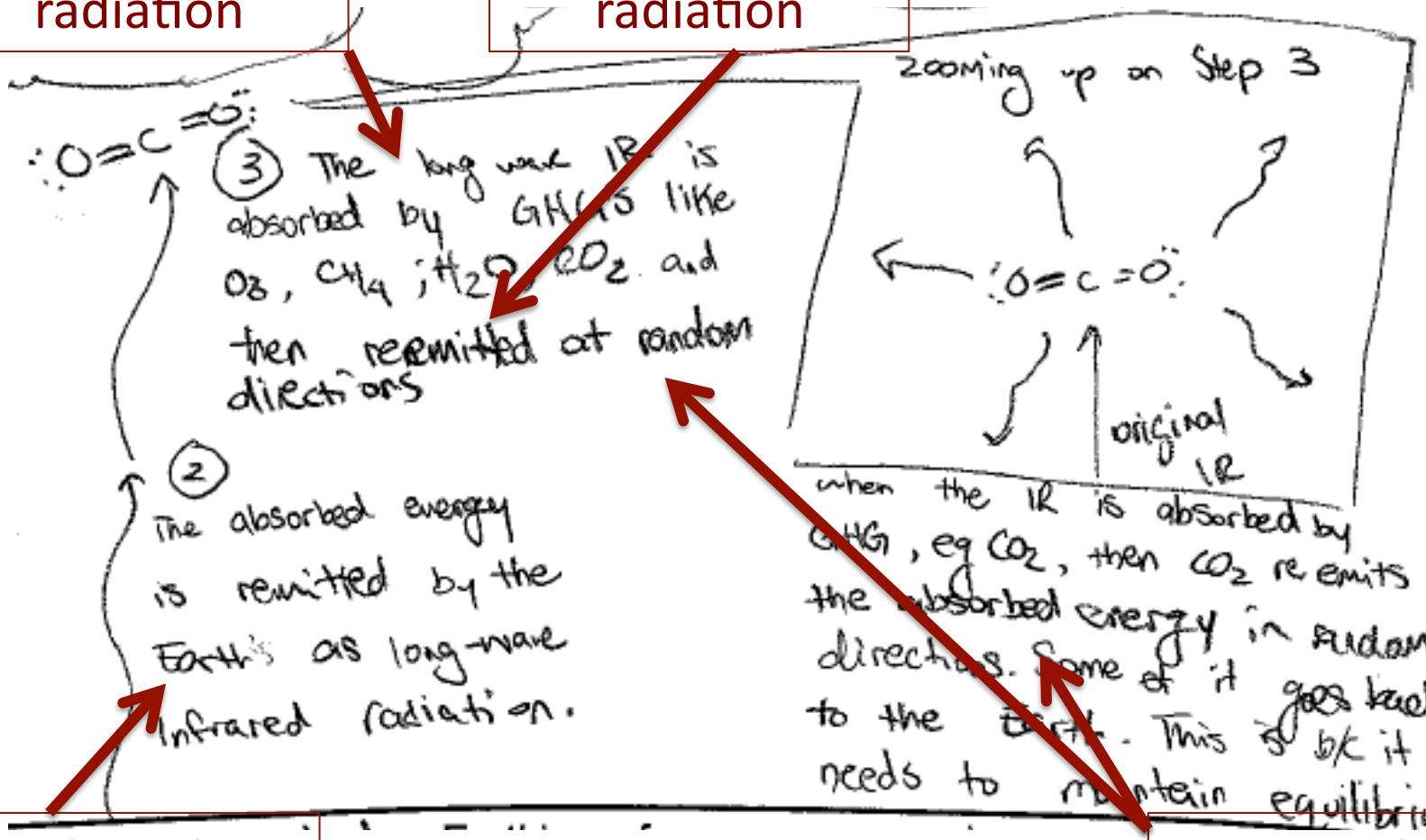
*Johnson and Reynolds, 2005


On a Friday…
Pre-Test
3 days
Common Lesson
Same day
"Mid"-Test (sketch only)
2 days
4 days
Simulation Lesson (PhET)
OR (randomly assigned)
Data Lesson (Absorption Spectra)
5 days
3 days
Post-Test
7 weeks
Final Exam (sketch only)
3 months
Retention Test

Coding Concept Sketches (39 statements)

GHGs absorb radiation

GHGs re-emit radiation

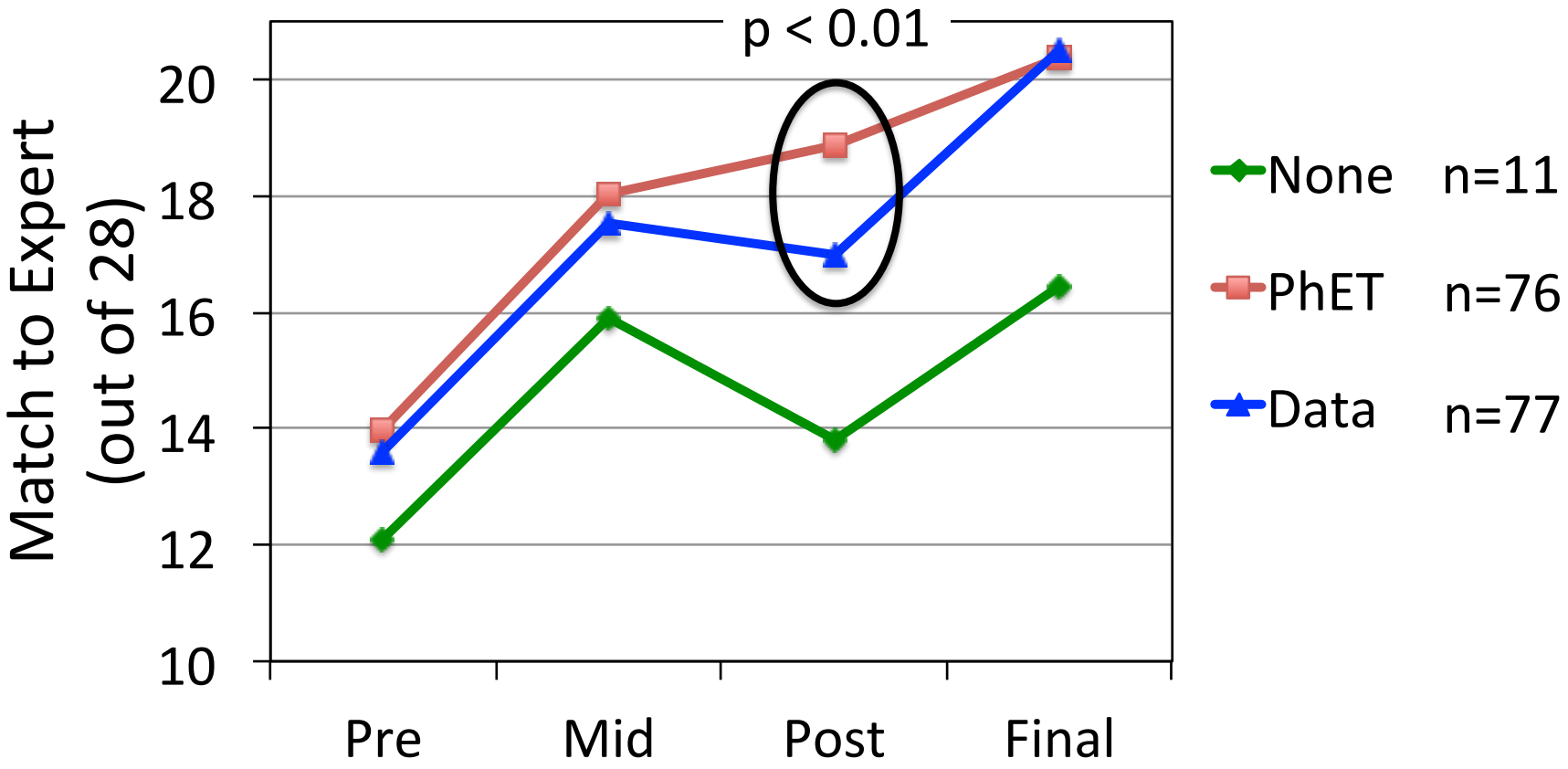


Earth's surface emits longwave radiation

Energy from GHGs goes in any direction

Concept Sketch Scores Over Time

(average scores)



1 Item: GHGs absorb radiation

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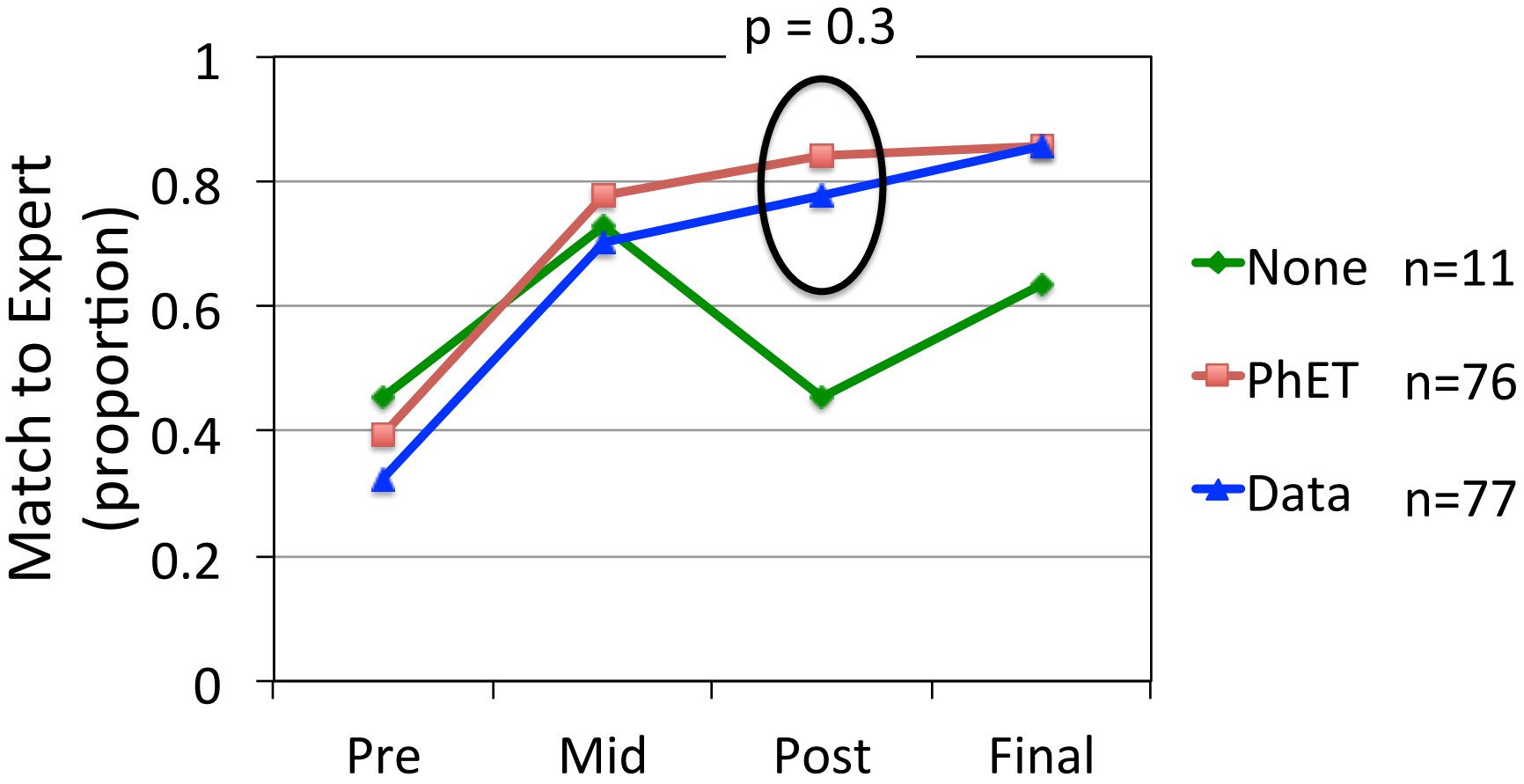

1 Item: GHGs emit radiation

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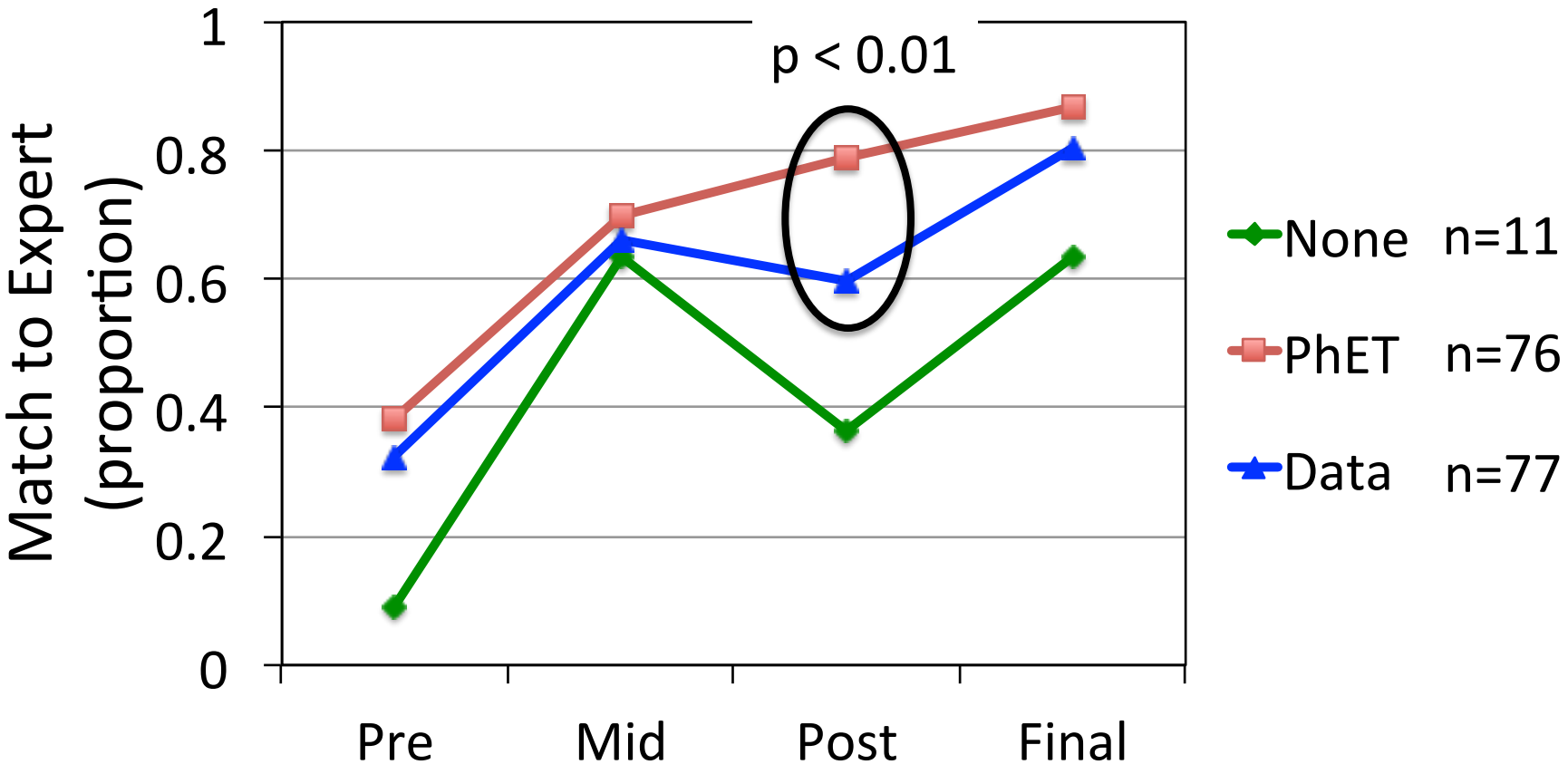

1 Item: GHGs emit in any direction

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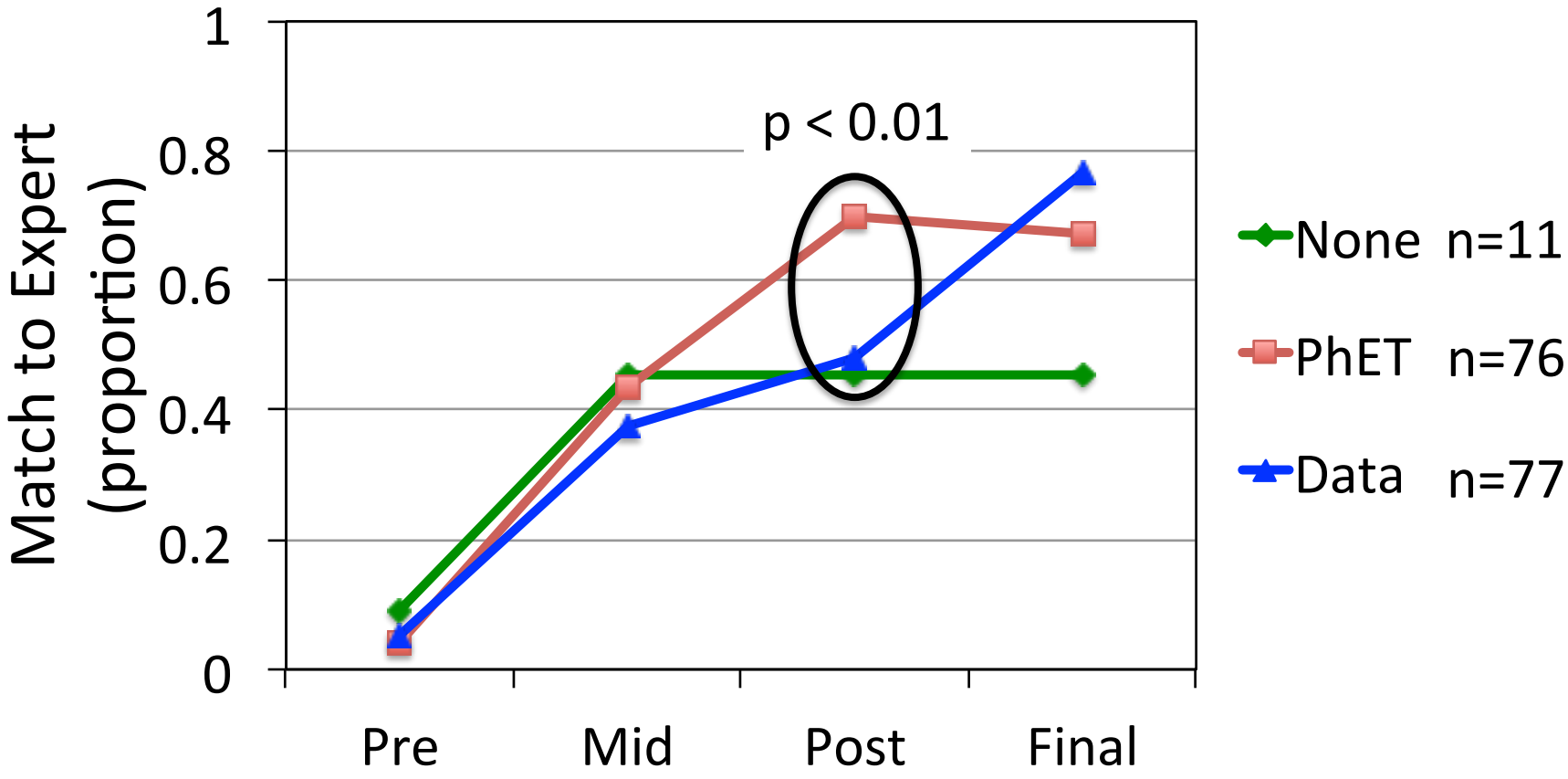
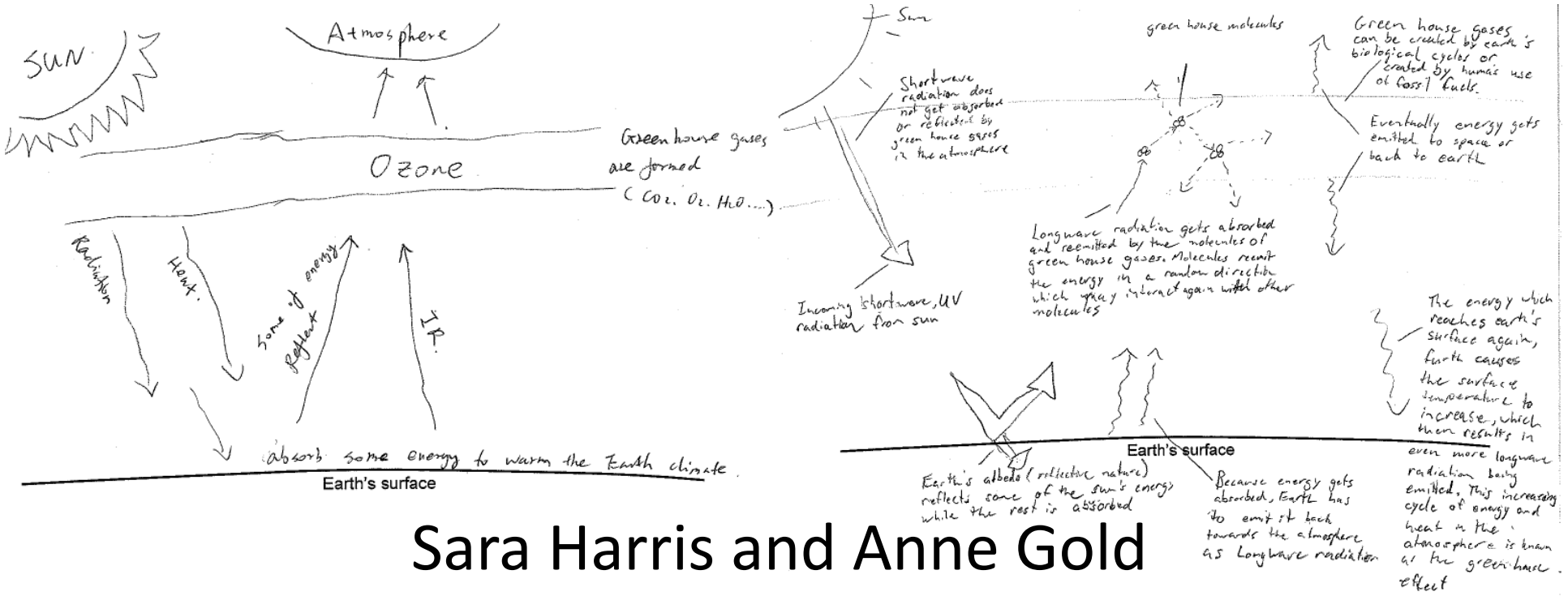


Next steps

- Statistically generate student mental models
- Groundtruth “expert” mental model with experts and instructors who teach the greenhouse effect.
- Evaluate progression of learning, including retention
- Compare multiple choice to concept sketching
- Identify conceptual targets for future instruction

Student Mental Models of the Greenhouse Effect: Retention Months After Interventions



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The setting & participants

- Large research university
- Intro course: “Atmospheres and Oceans”
- Open to all: wide diversity of backgrounds
- Enrollment = 248 *(average course grade=75%)*
- 164 students wrote 4 assessments during term *(average course grade = 81%)*
- 27 students wrote an additional “retention” assessment *(average course grade = 86%)*

1 Common lesson + 2 Contrasting Lessons

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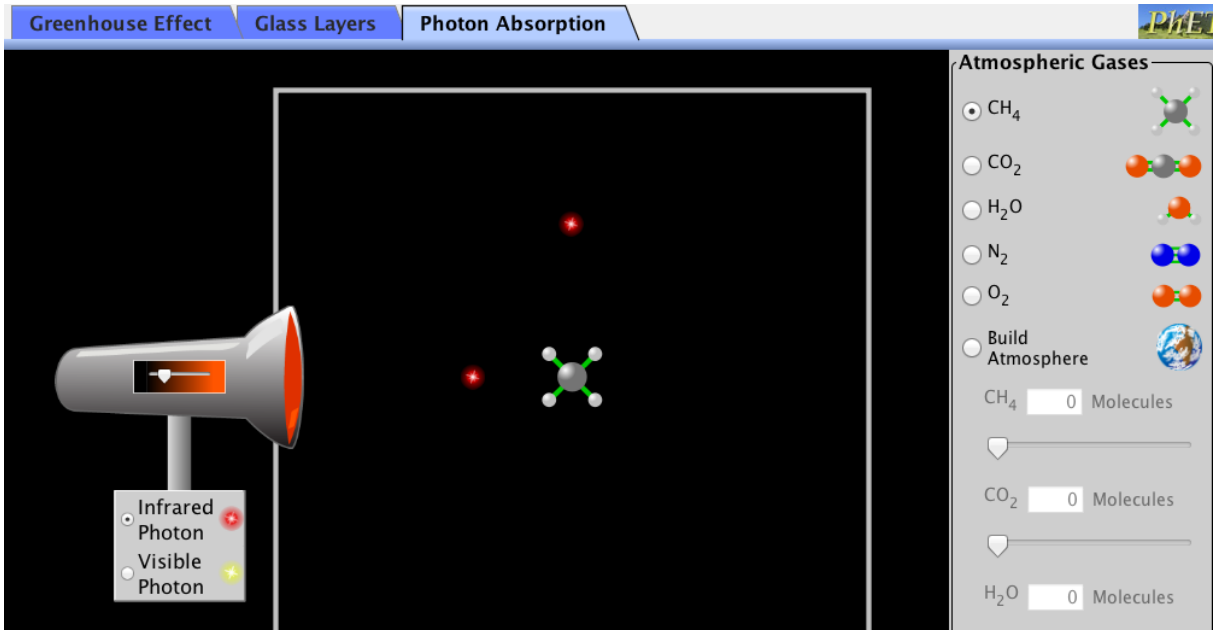

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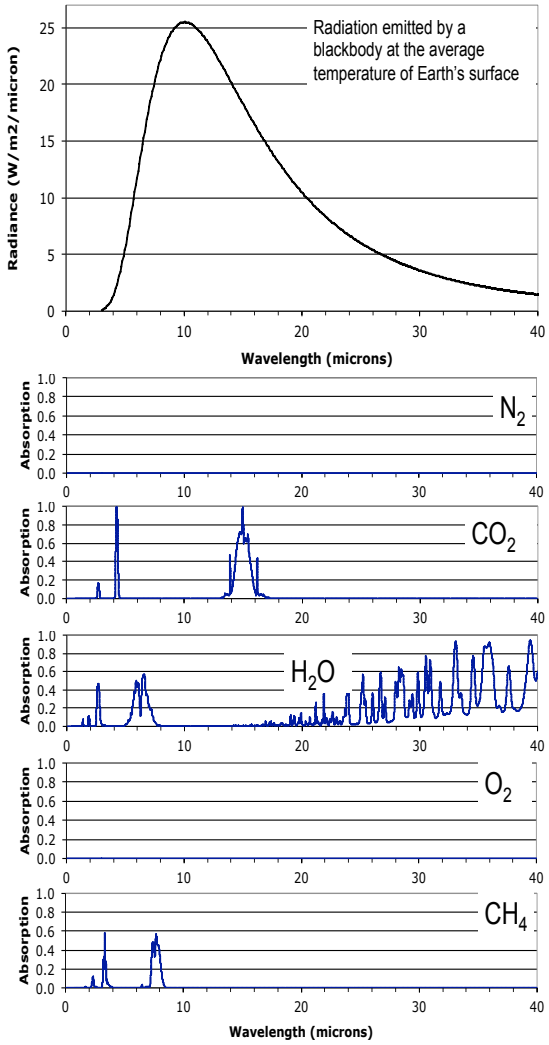

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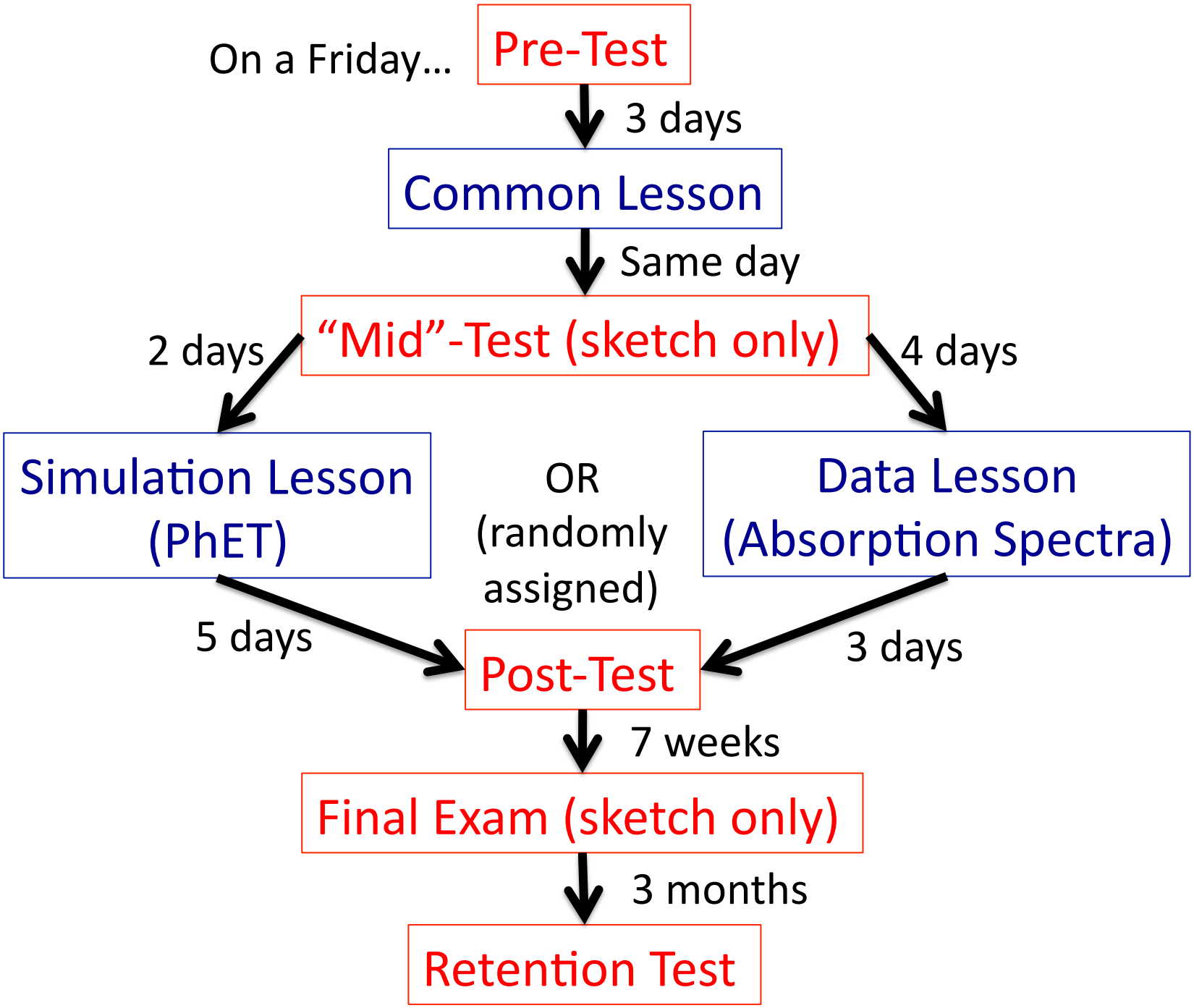
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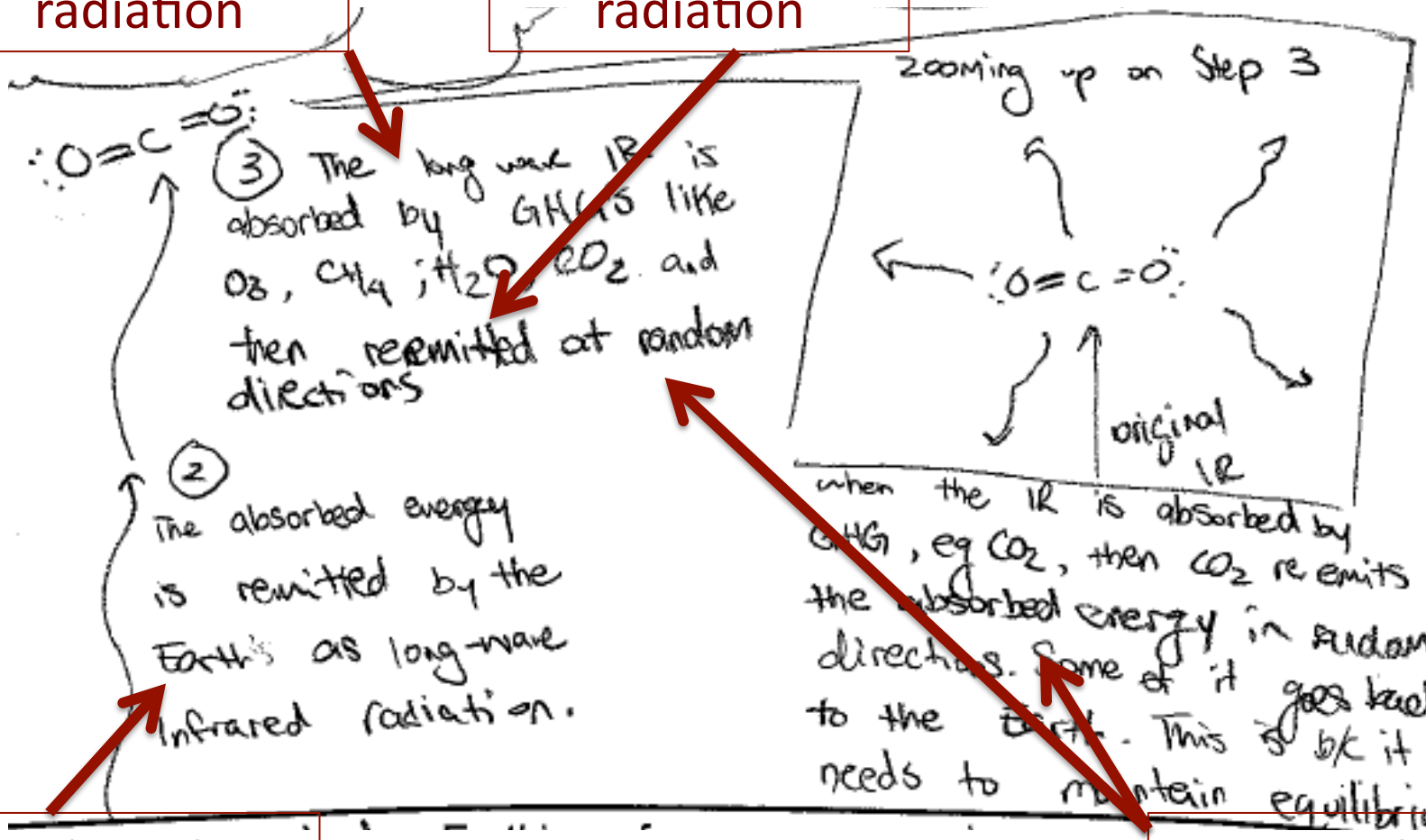

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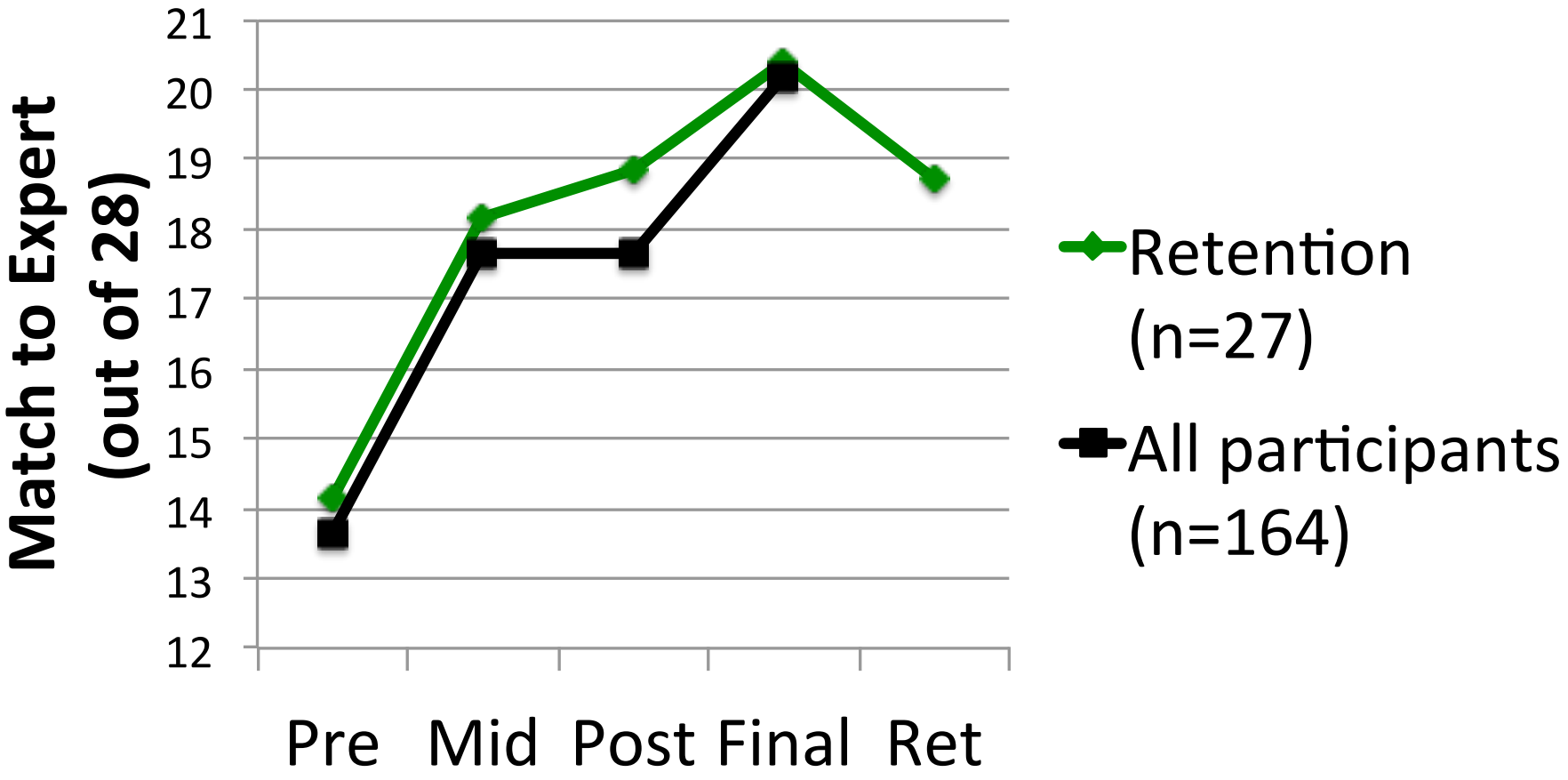
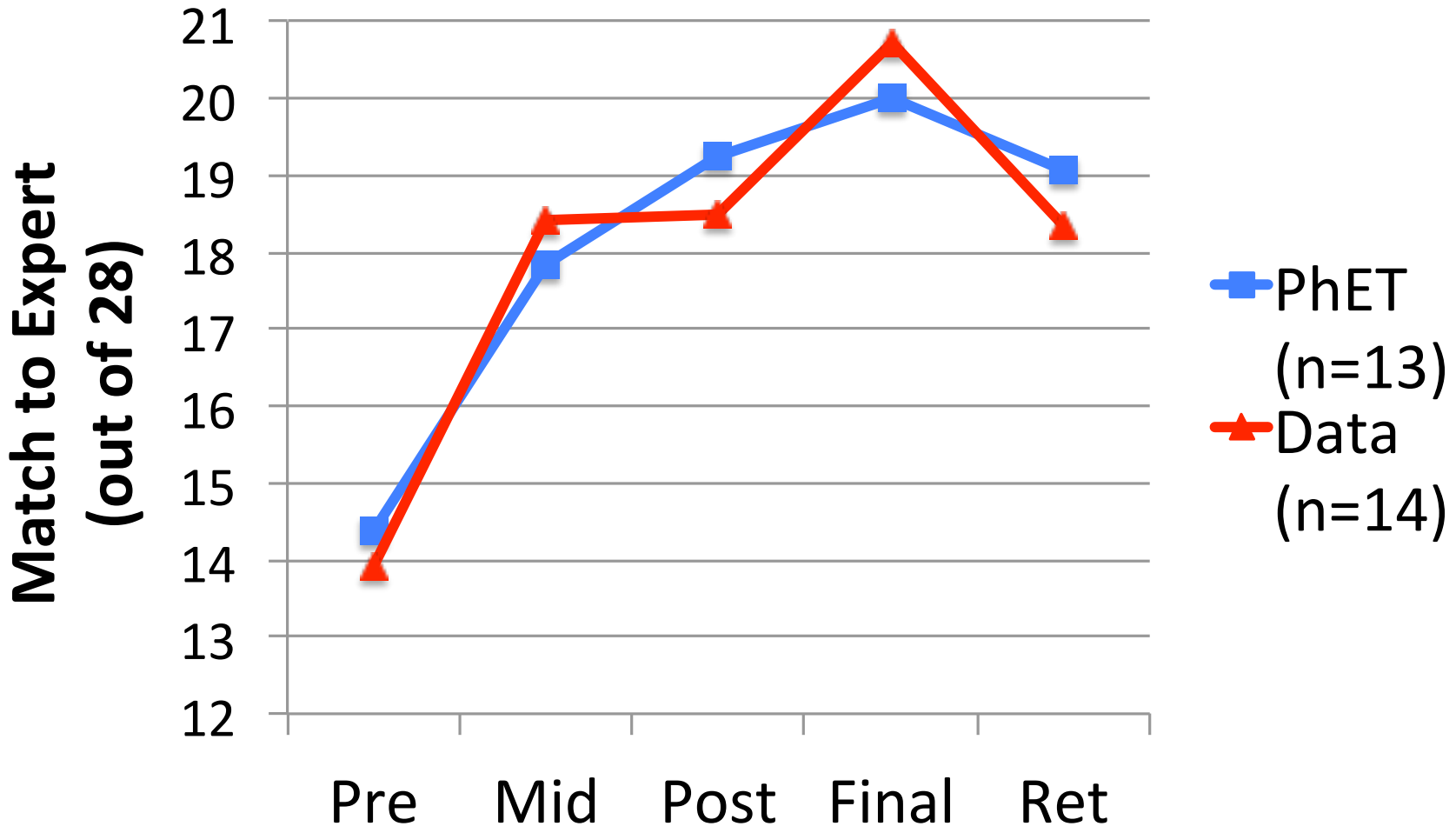


2 groups have statistically the same average on each of the first 4 tests

Concept Sketch Scores Over Time

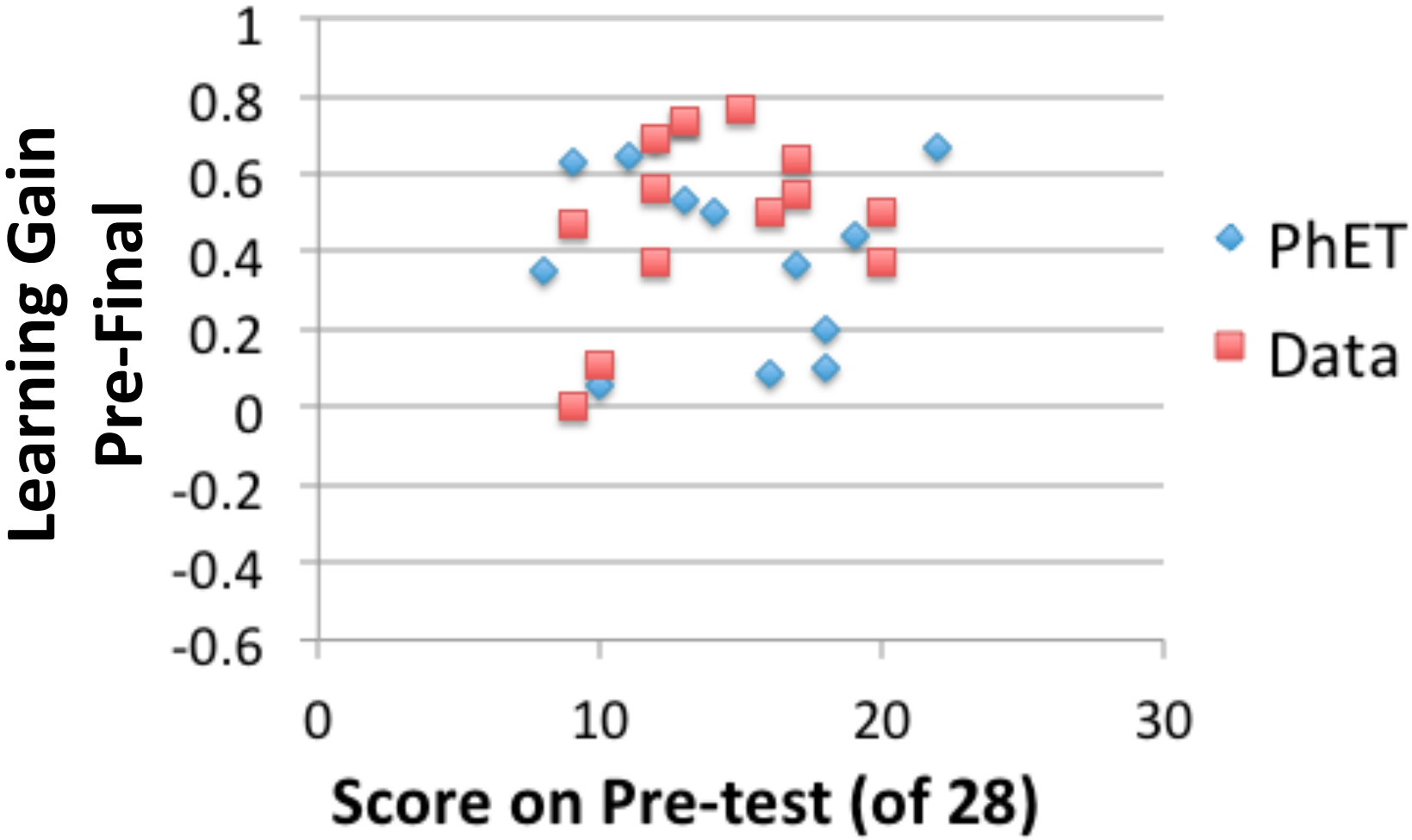
(average scores, retention group only)



2 groups have statistically the same average on each of the 5 tests

Learning Gain Between Pre- and Final

Average Gain ~0.45



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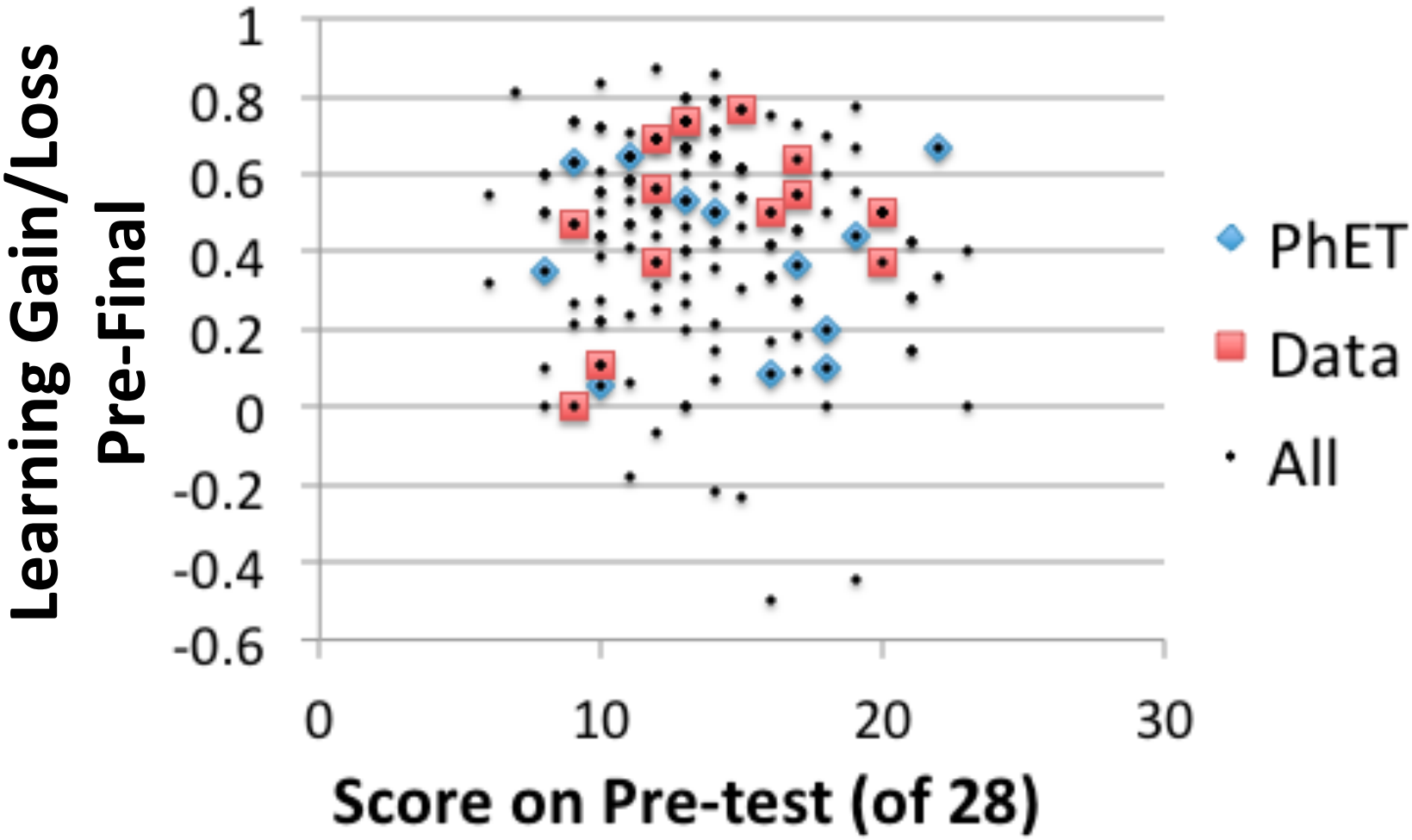
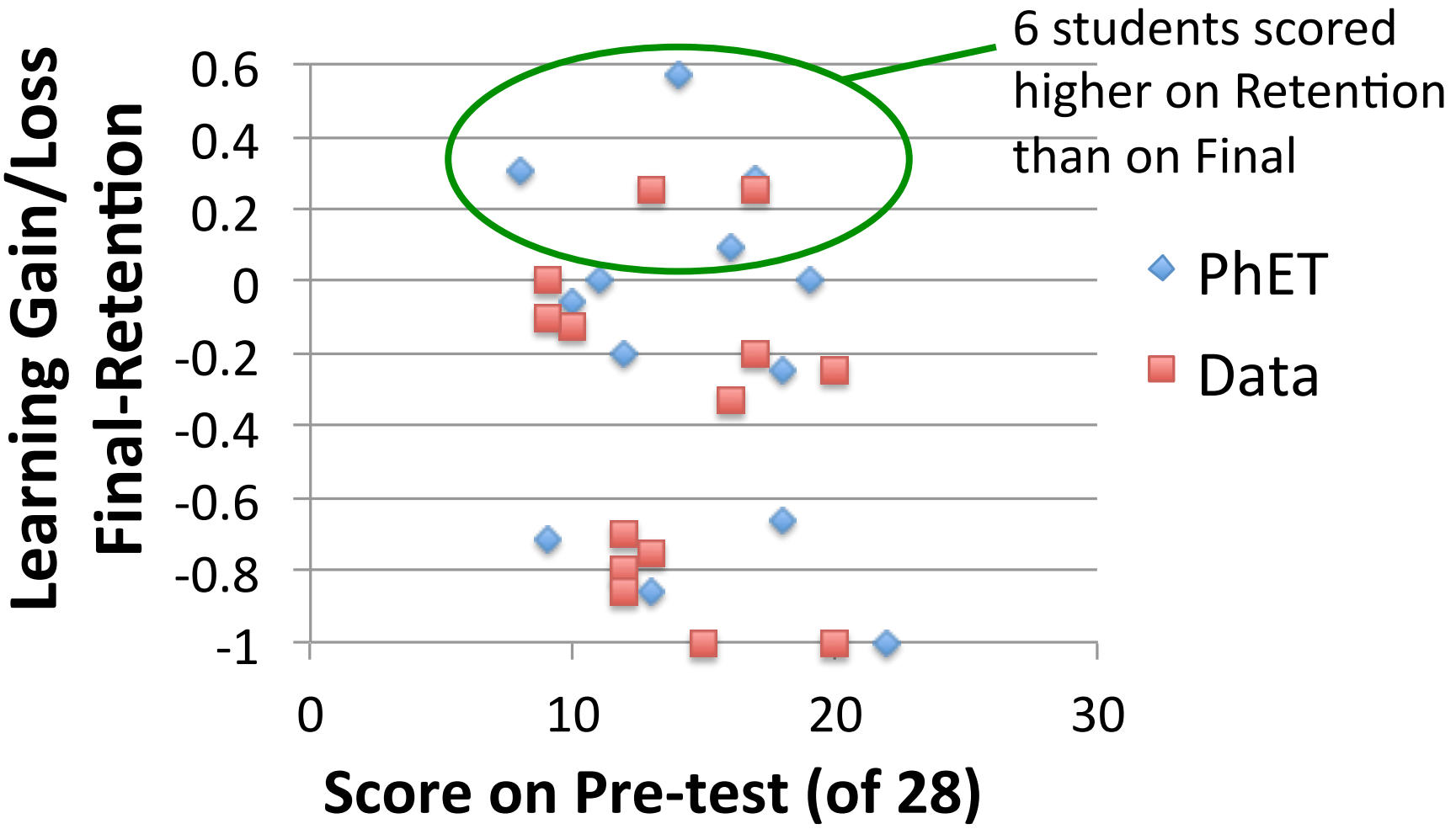


Learning Gain/Loss Between Final and Retention

Average Loss ~0.3



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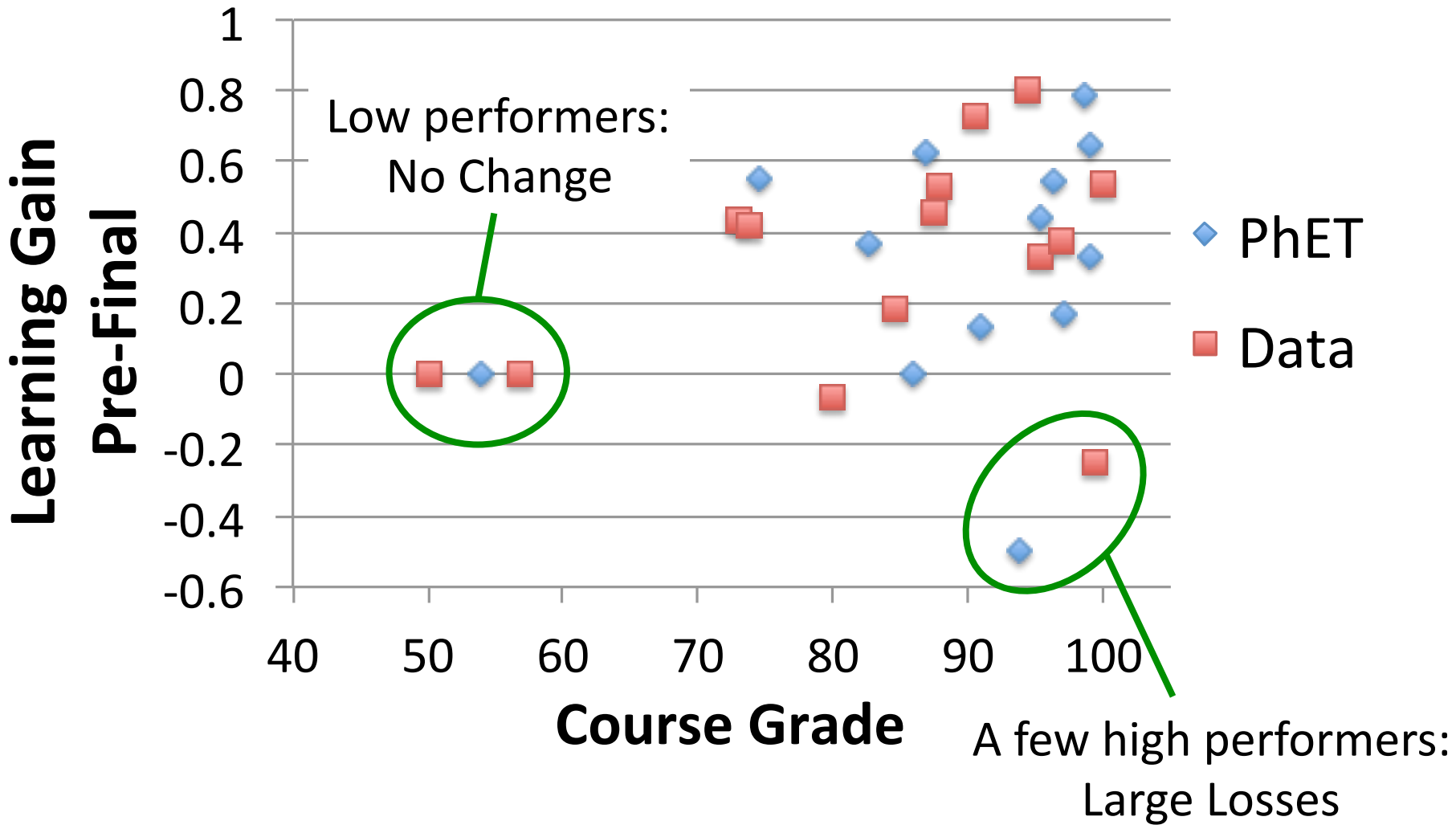
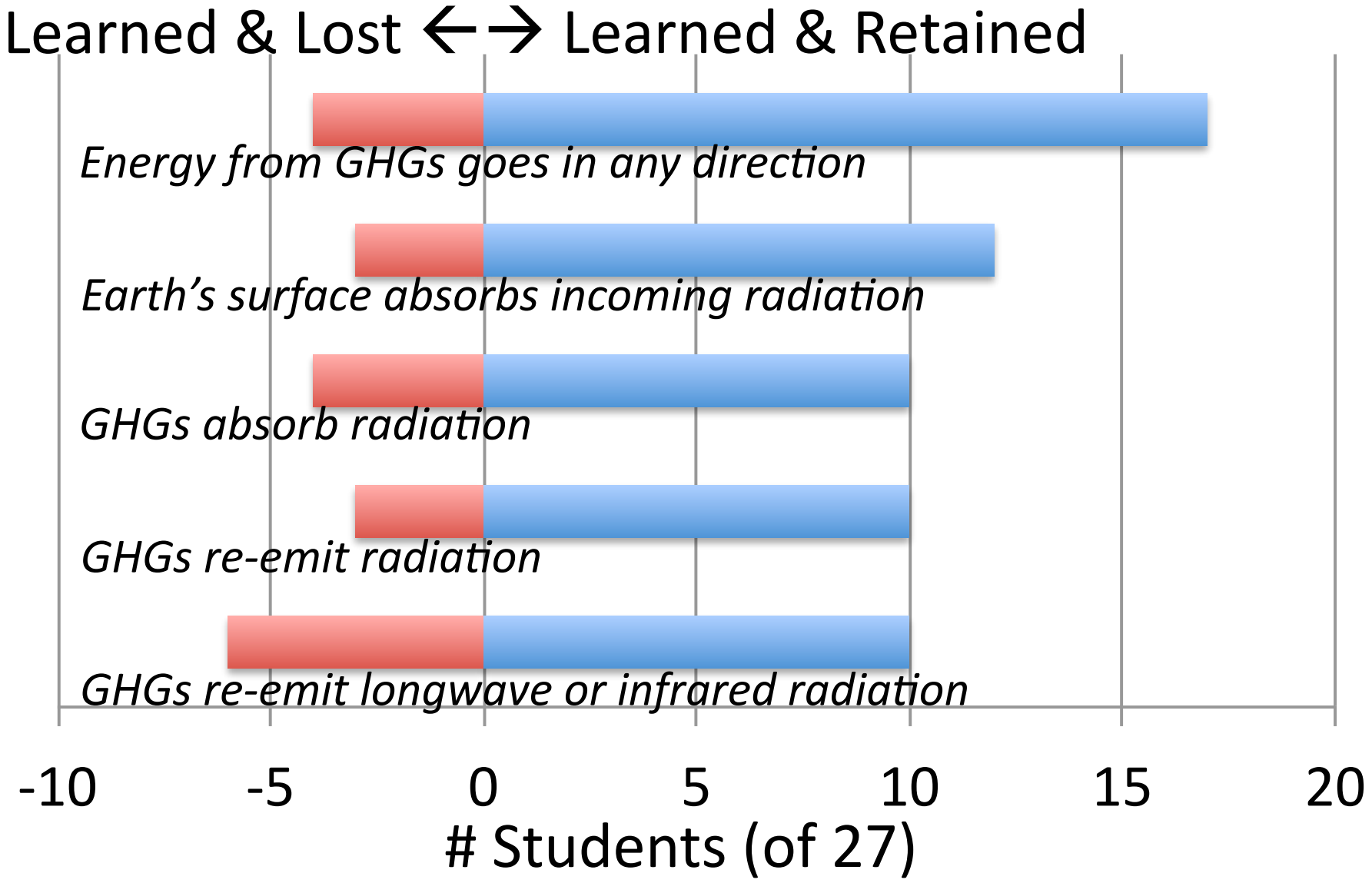
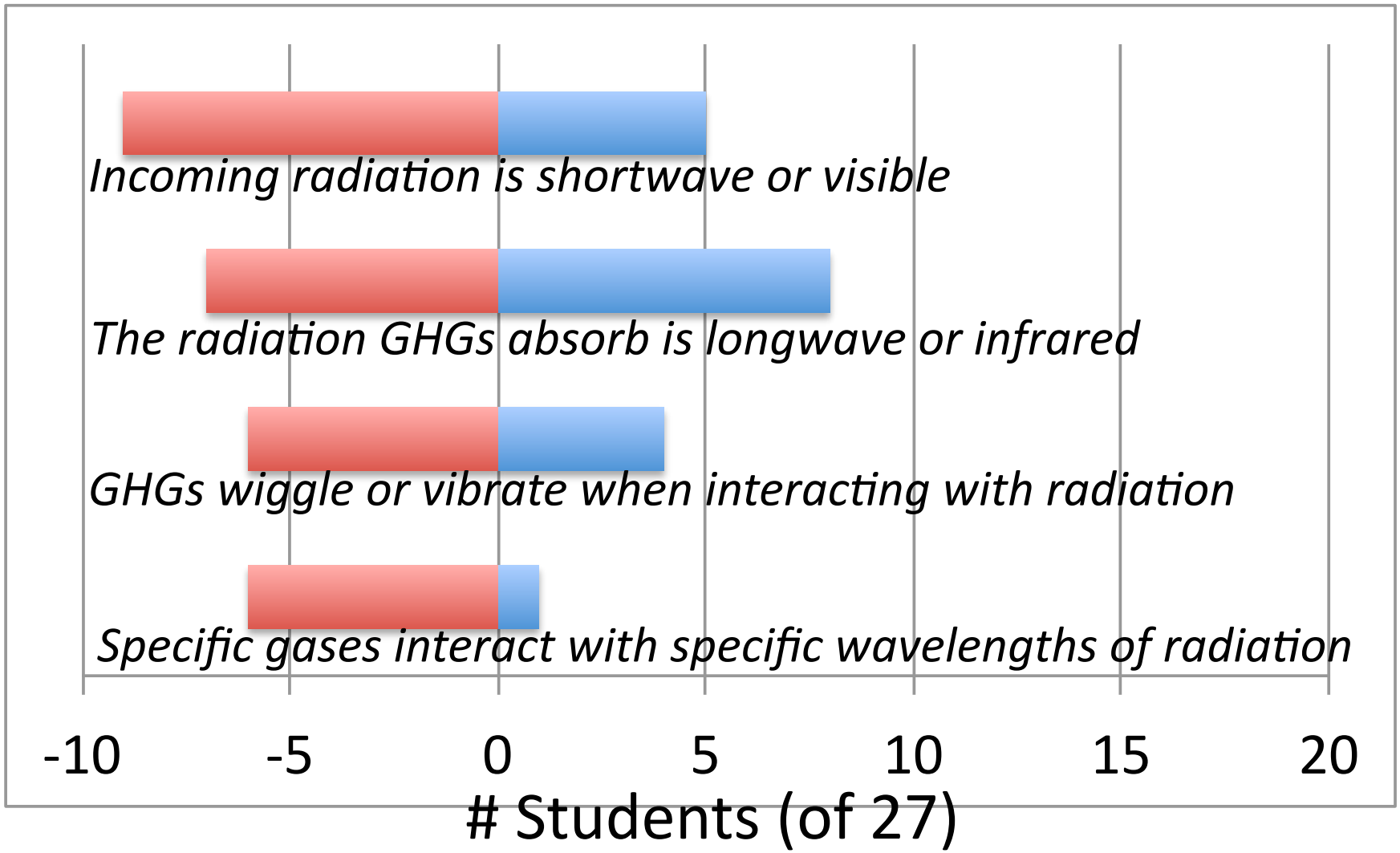


Key Statements most strongly Learned (after Pre-test) & Retained

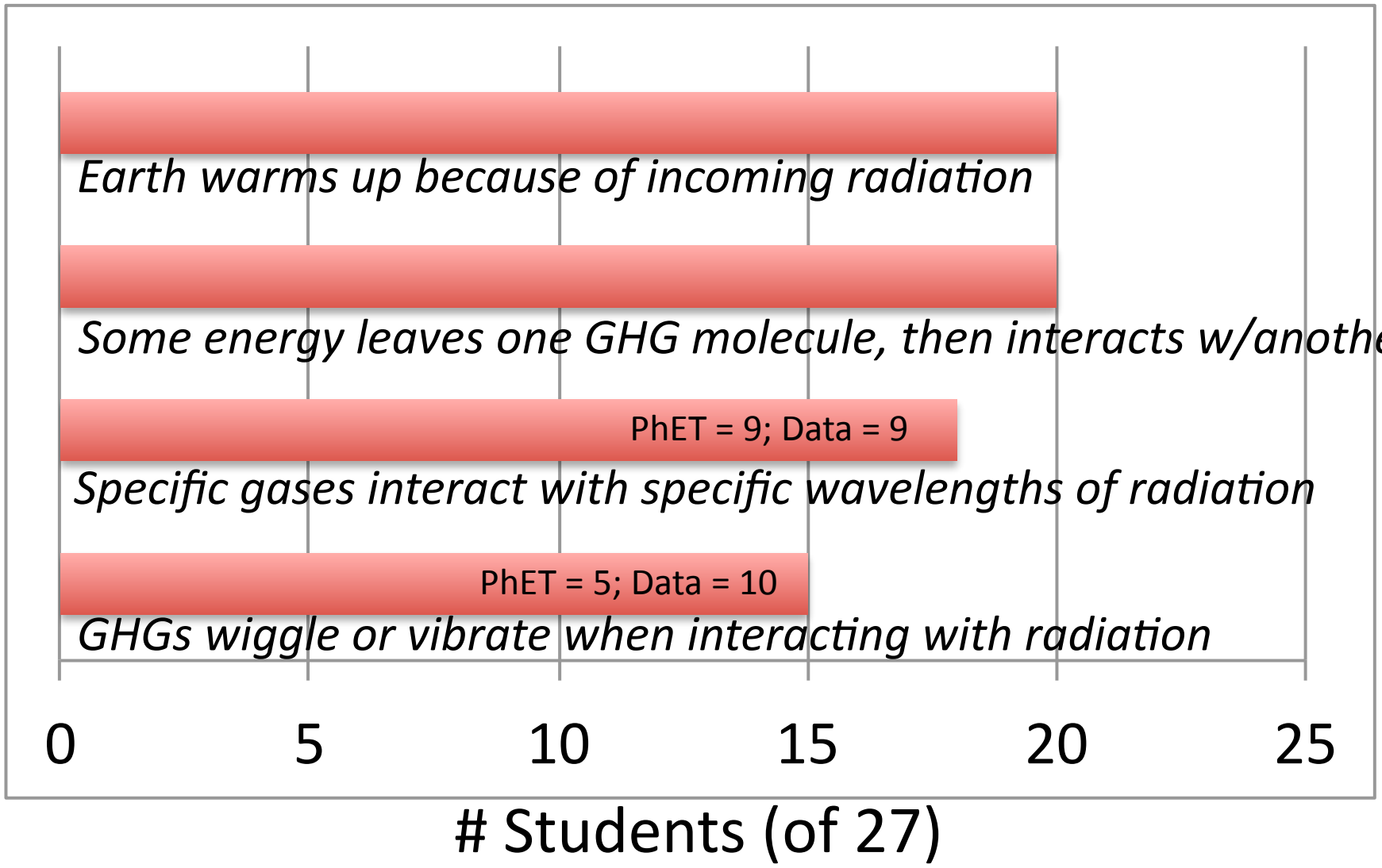


Key Statements most strongly Learned (after Pre-test) & Lost

Learned & Lost ←→ Learned & Retained



Key Statements Not Learned



Implications for Instruction?

- 3-4 months after the course ended, students retained about 2/3 of their ideas acquired after the pre-test.
- No large difference between PhET and Data students
- "Stickier" components learned and retained:
  - **GHGs absorb & re-emit radiation (in random directions)**
- "Slippery" components learned and lost:
  - **Specific gases interact w/specific wavelengths**
  - **Gases wiggle and vibrate**
- Lessons may not be reaching low performers (but n is small)

Questions:

- How good is good enough?
- What statements/ concepts do we really care about?
- Are there "threshold" concepts, i.e. if they learn and retain ___ they don't lose as much?