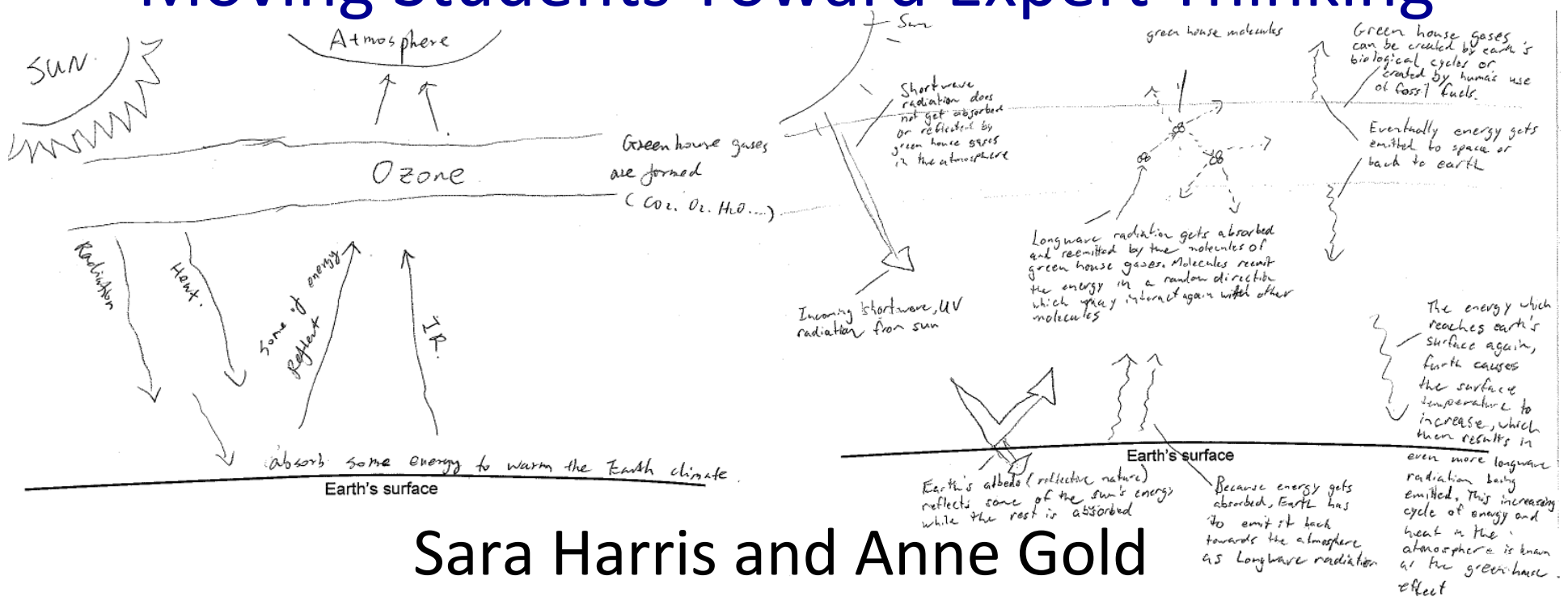


# University Students' Mental Models of the Greenhouse Effect: A Comparison of Two Learning Activities in Moving Students Toward Expert Thinking



Sara Harris and Anne Gold



a place of mind  
THE UNIVERSITY OF BRITISH COLUMBIA



# 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)

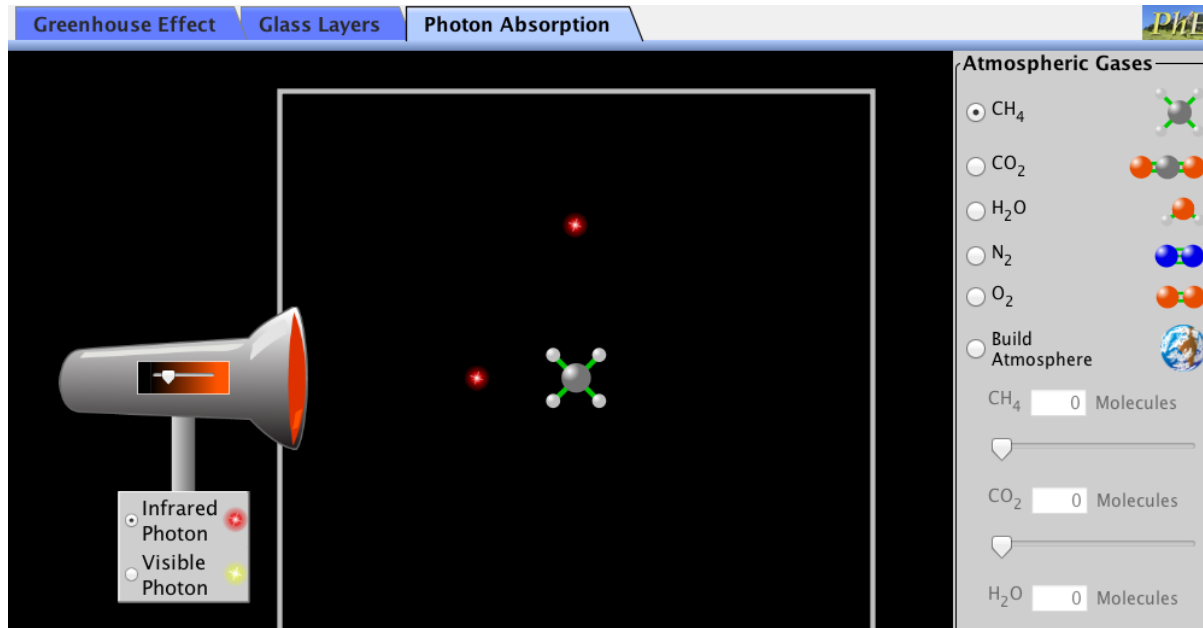
# Learning Goals

(Aligned with Lessons, aligned with Assessments)

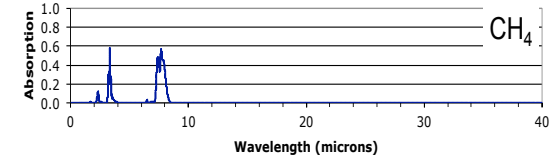
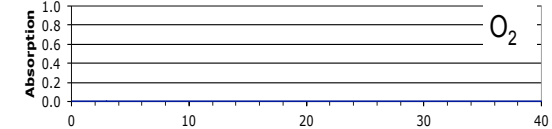
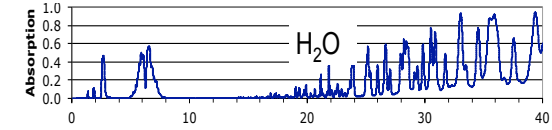
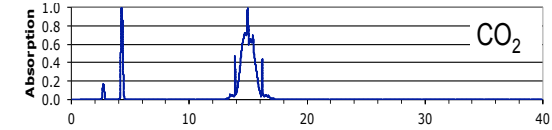
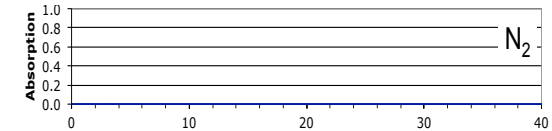
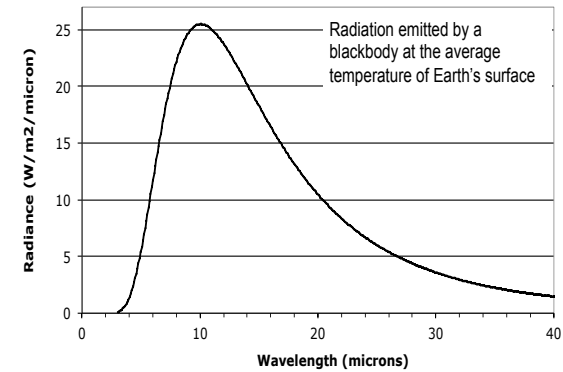
1. Identify greenhouse gases; identify non-greenhouse-gas air molecules
2. Differentiate between short wave radiation from the Sun and long wave radiation from the Earth
3. Contrast the molecular structure of greenhouse gases versus non-greenhouse gases (common air molecules)
4. Explain how the greenhouse 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))

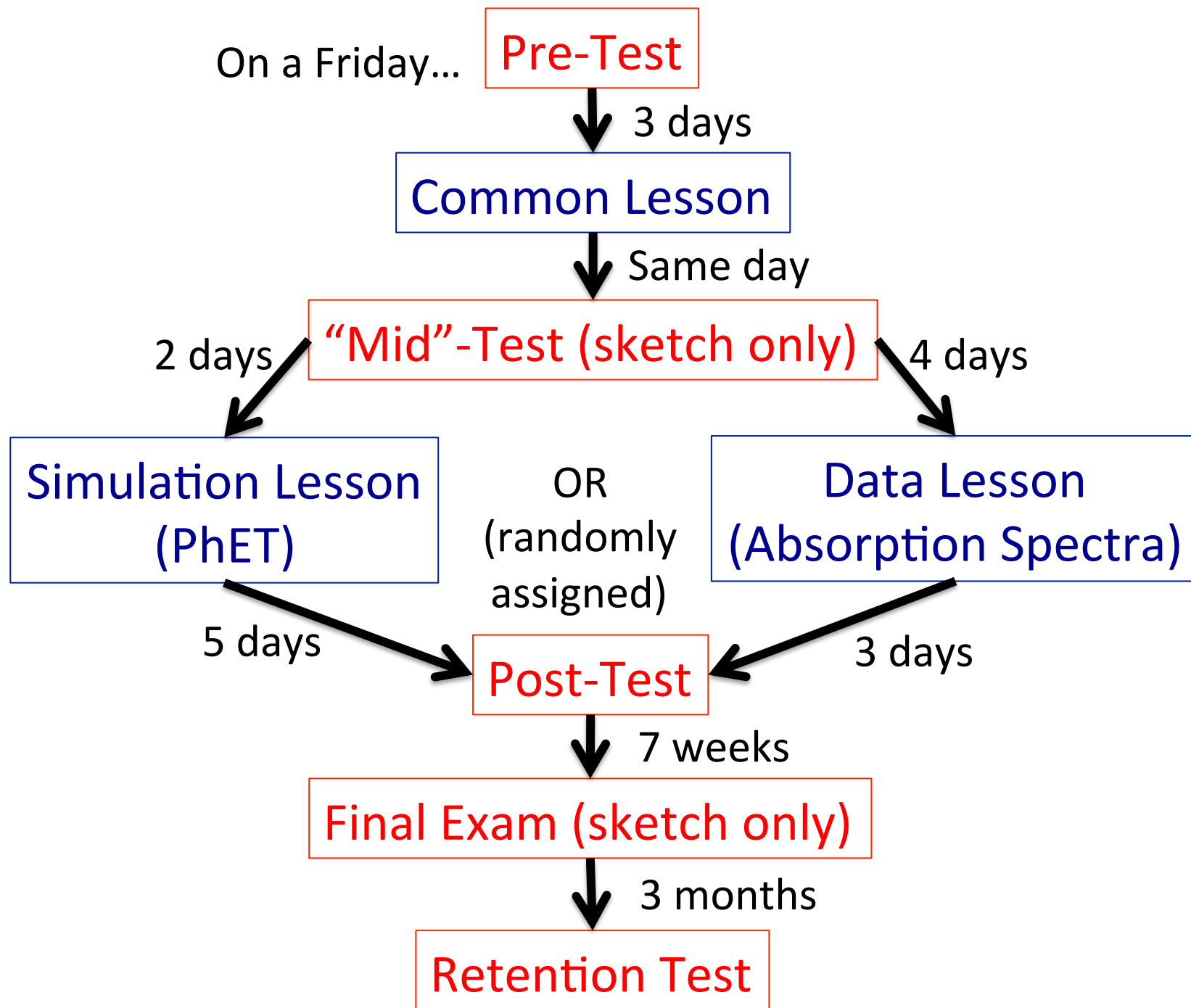
3 Short Answer questions

9 Multiple Choice questions

*Questions developed and modified from existing questions.*

*Validated with student interviews and expert review.*

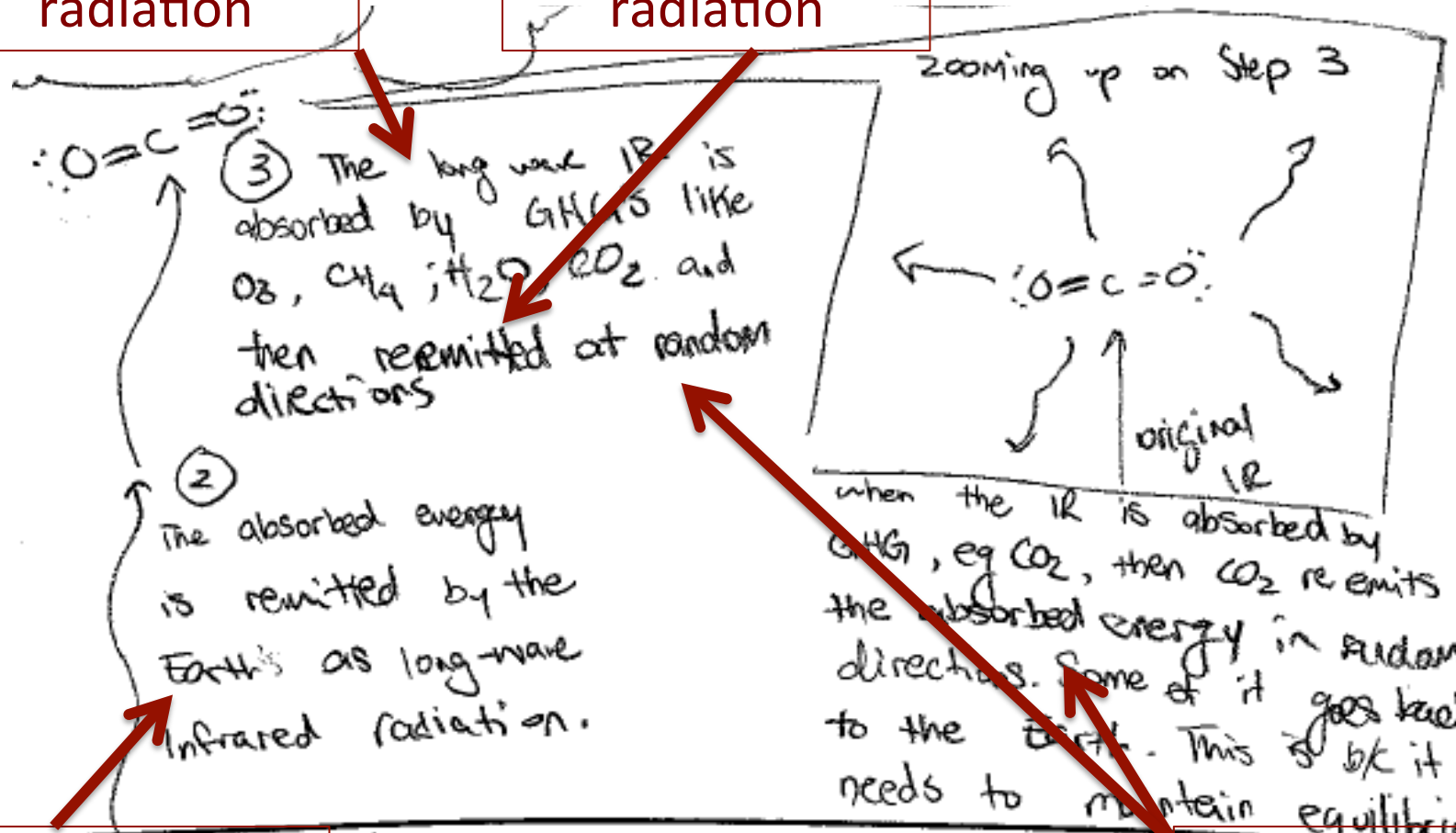
\*Johnson and Reynolds, 2005



# Coding Concept Sketches (39 statements)

GHGs absorb radiation

GHGs re-emit radiation

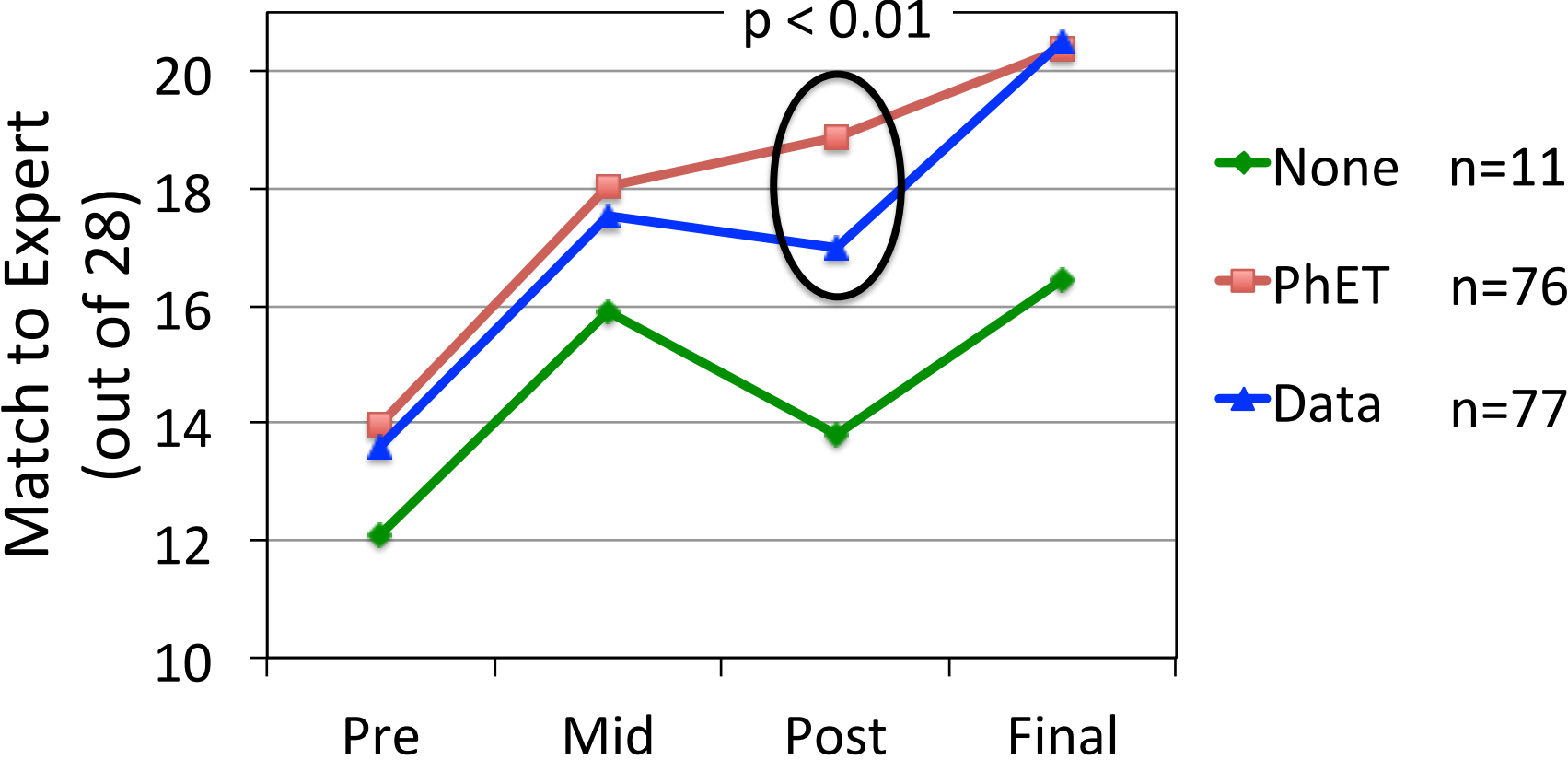


Earth's surface emits longwave radiation

Energy from GHGs goes in any direction

# Concept Sketch Scores Over Time

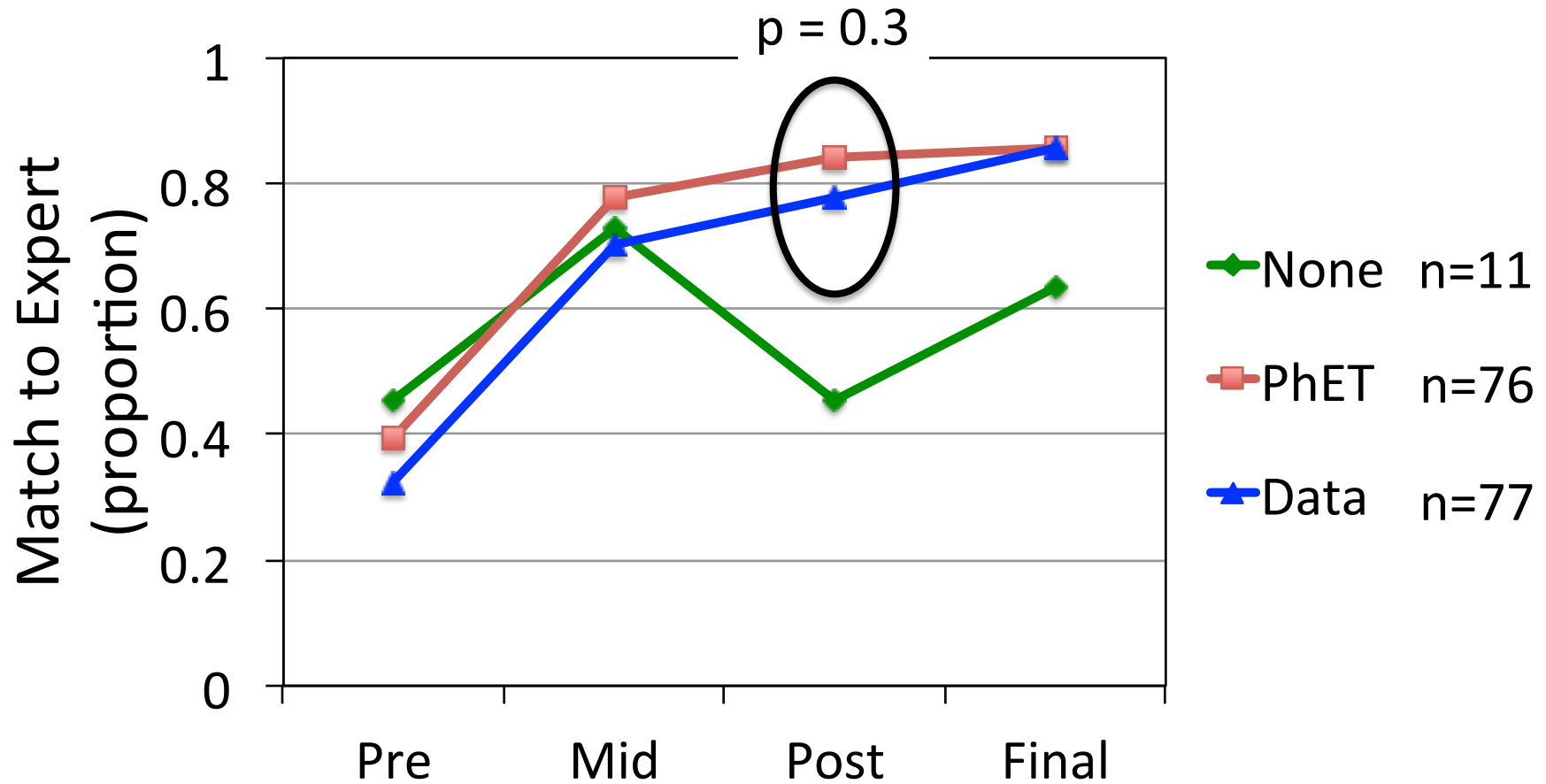
(average scores)





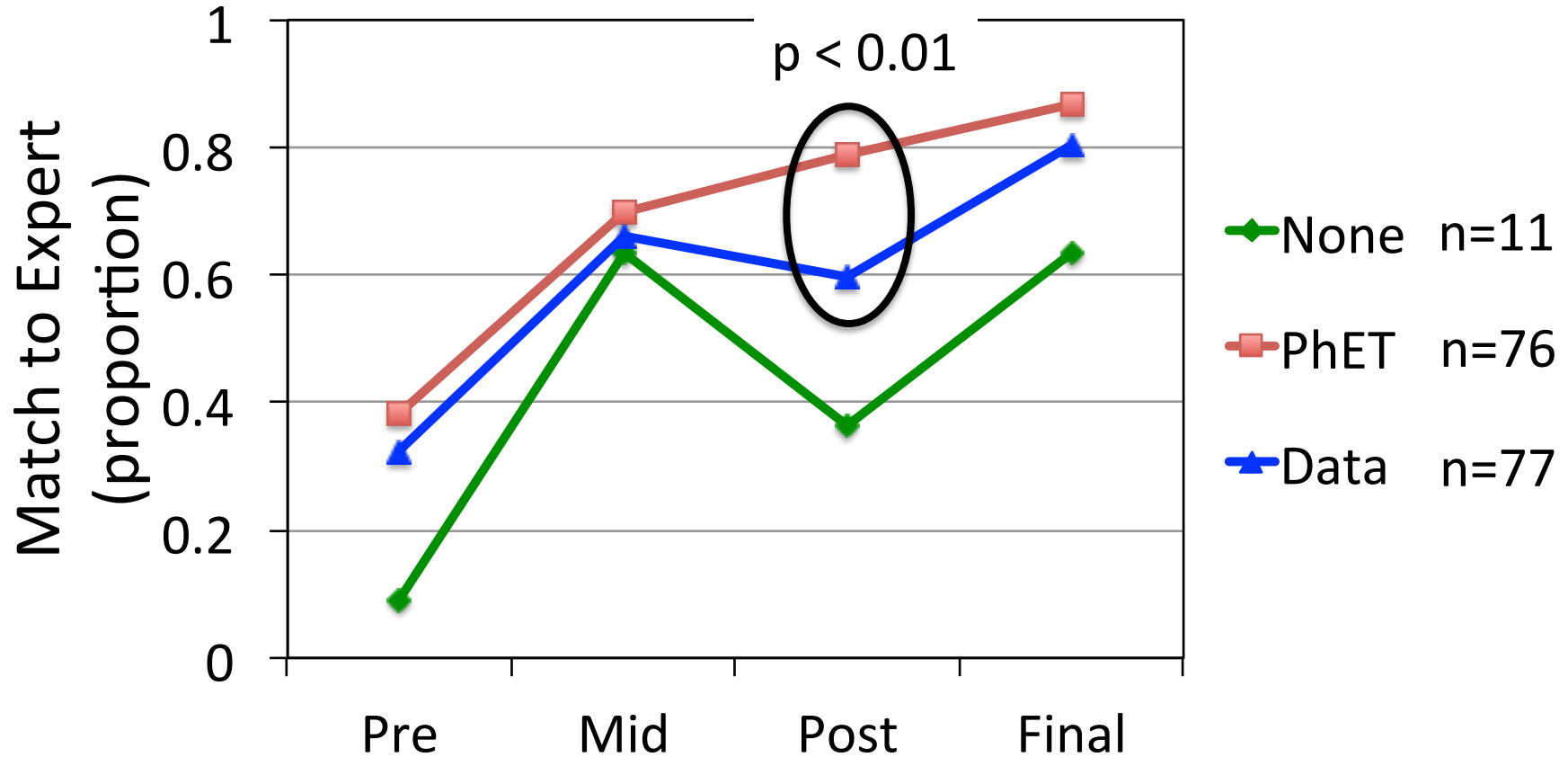
# 1 Item: GHGs absorb radiation

(average scores)



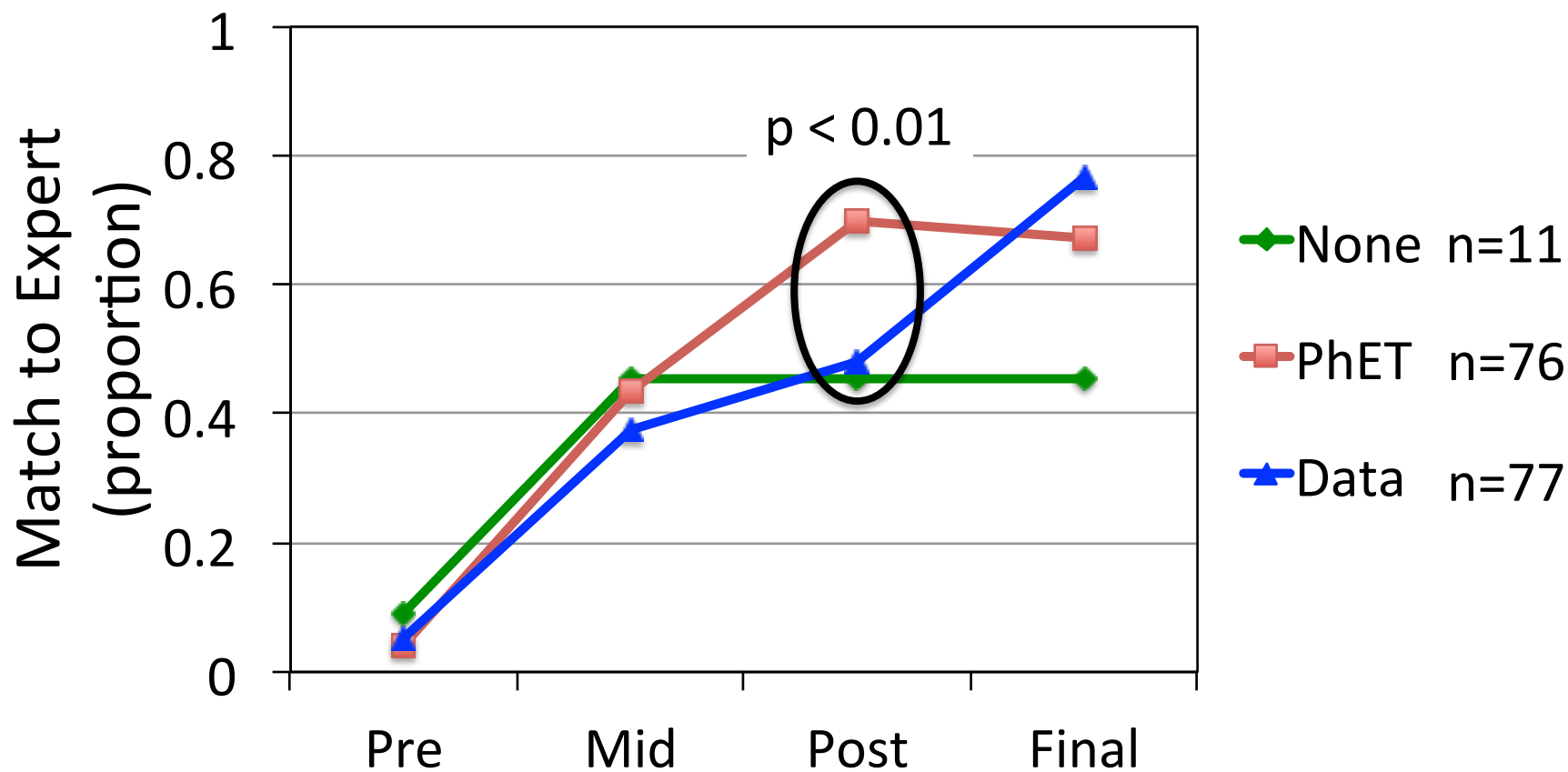
# 1 Item: GHGs emit radiation

(average scores)



# 1 Item: GHGs emit in any direction

(average scores)



# 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