Can a Day 1 group worksheet improve student application of math in a climate change course?

(Looks unlikely, given what we've tried so far)

Sara Harris, Tara Ivanochko,

Phil Austin, Nathan Roberson

(with help from Ido Roll and a CTLT SoTL grant)

EOSC 340: Global Climate Change

- Pre-reqs: First year math, physics, and chemistry
- Pre-class prep and quizzes every class
- Weekly homework
- In-class clickers and worksheets
- Math practice problems and review links
- 2 midterms and a final
- Enrollment ~140/term, 2 terms/year

The issue: Students struggle with applying their math in context.

What we tried

DAY 1

Math worksheet:
1st year math applied to climate-related problems (n=69)

vs

Greenhouse worksheet:
Conceptual questions about greenhouse effect (n=52)

DAY 1

Pre-Test (low stakes):
Both math and conceptual questions (n=123)

DAY 12

Midterm 1 (high stakes):
Math-heavy midterm

DAY 25

Post-Test (low stakes):
Same questions as Pre-Test (n=105)

86 students did all four activities (others missed at least one)
50 in "Math" worksheet group; 36 in "Greenhouse" worksheet group

The Low Stakes Pre-Post Test

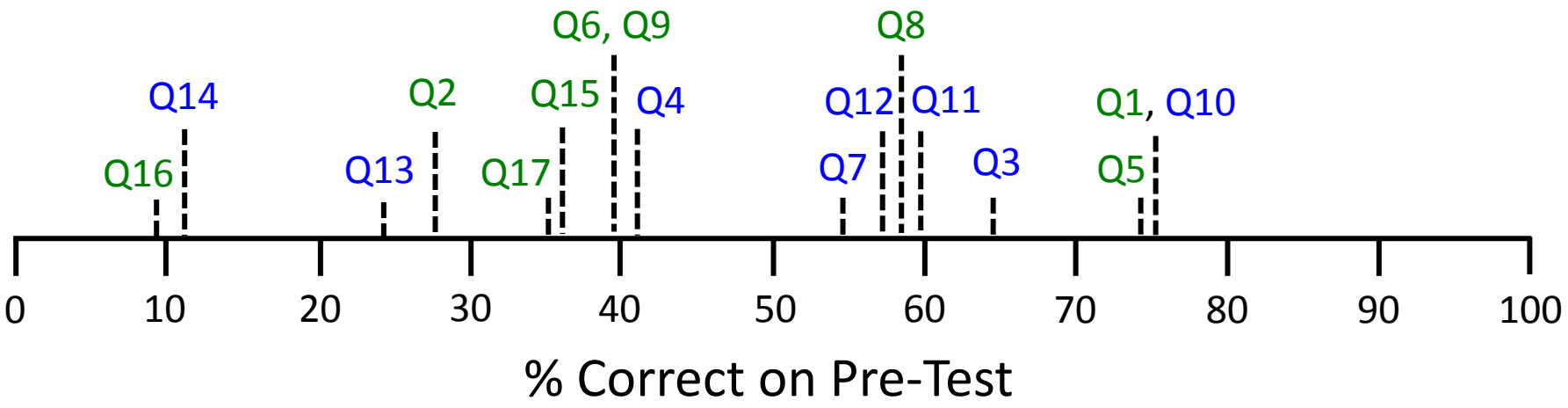
17 questions

- 9 conceptual questions from a validated concept inventory about climate science (not math)
- 8 applied math questions
  - 1 asks "how would you solve…"
  - 2 involve integration
  - 1 involves differentiation
  - 2 involve graph-reading (one of which also involves integration)
  - 1 involves units associated with an integral
  - 1 involves the concept of isostacy with calculations
  - 1 involves the concept of isostacy, without calculations

Broad Range of Difficulty

Math Questions

Conceptual Questions



Example Questions

3) What would you do to solve the following problem? Suppose an originally empty tub has an inflow of water of 10 kg/hour and an outflow of water that increases with time by 2t kg/hour, where t is the time in hours. What is the mass M of water in the tub after 2 hours? That is, what is M after 2 hours if:

$$\frac{dM}{dt} = 10 - 2t$$

For this, the question is "what would you do to solve this problem?"

A. Integrate dM/dt from t=0 to t=2 hours
B. Evaluate dM/dt at t=2 hours
C. Set dM/dt=0 and solve for t
D. Take the derivative of dM/dt and evaluate at t=2 hours
E. I do not know.

4) Now, solve the problem in Question 3 above. What is the mass M of water in the tub after 2 hours?

A. -2 kg
B. 5 kg
C. 6 kg
D. 14 kg
E. 16 kg
F. I do not know.

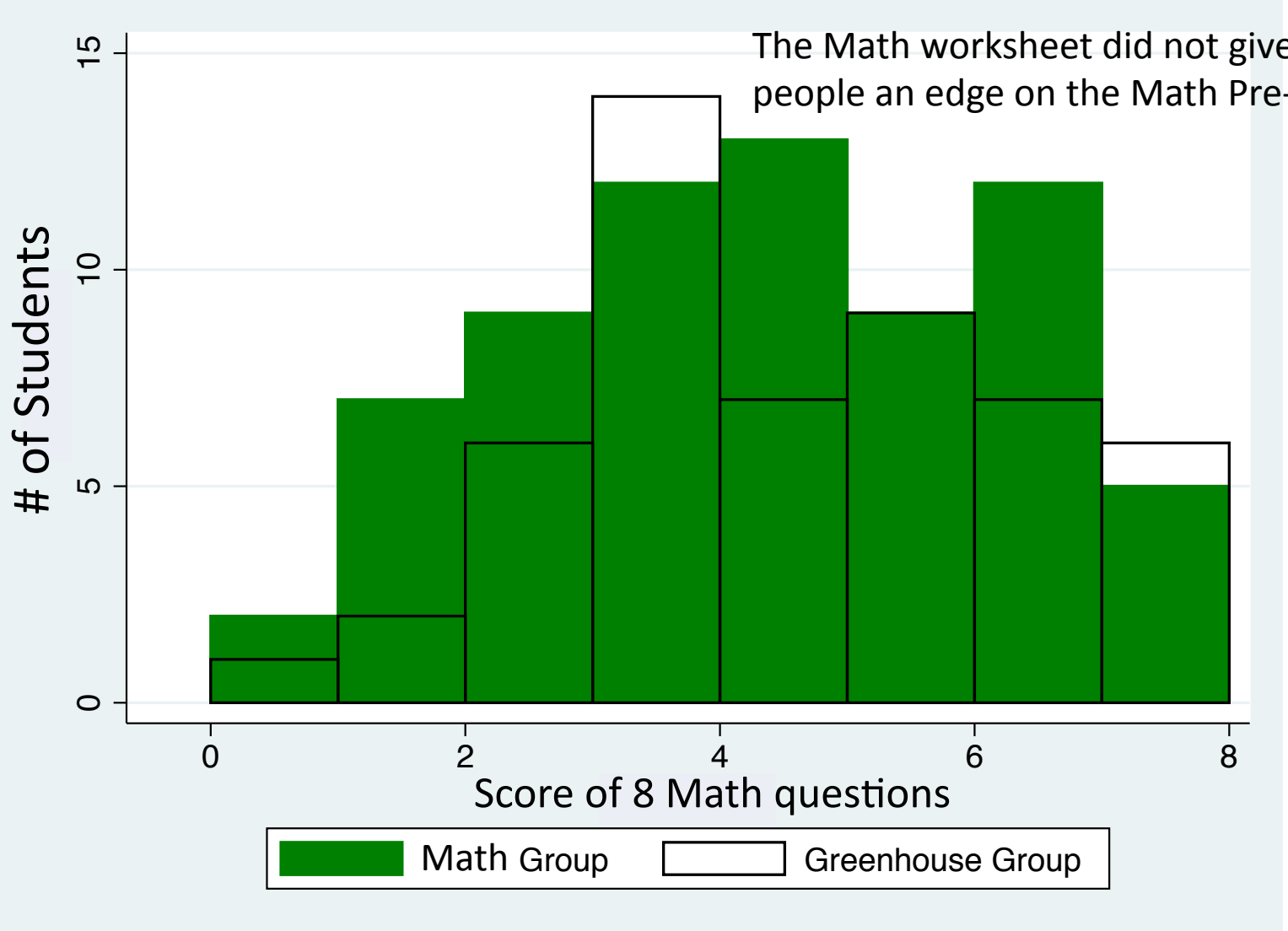
5) Which is the most common form of radiation given off by Earth's surface?

A. The Earth's surface mostly gives off visible radiation.
B. The Earth's surface mostly gives off infrared radiation.
C. The Earth's surface mostly gives off ultraviolet radiation.
D. Earth's surface does not give off radiation.
E. I do not know.

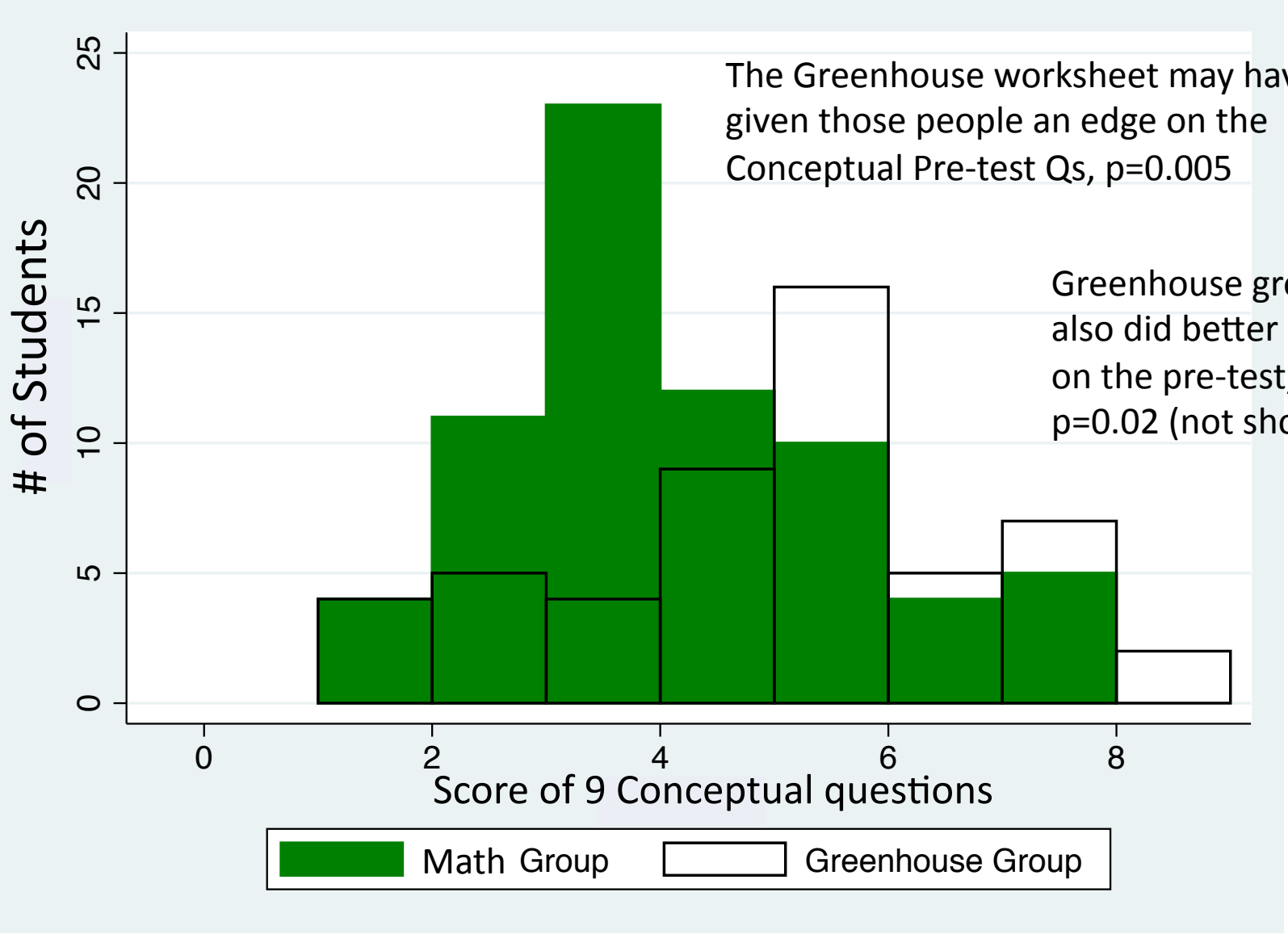
6) How much incoming sunlight do greenhouse gases absorb?

A. Greenhouses gases absorb almost no incoming sunlight.
B. Greenhouses gases absorb about half of the incoming sunlight.
C. Greenhouses gases absorb most incoming sunlight.
D. I do not know.

“Math” and “Greenhouse” groups average the same on the Math pre-test Qs

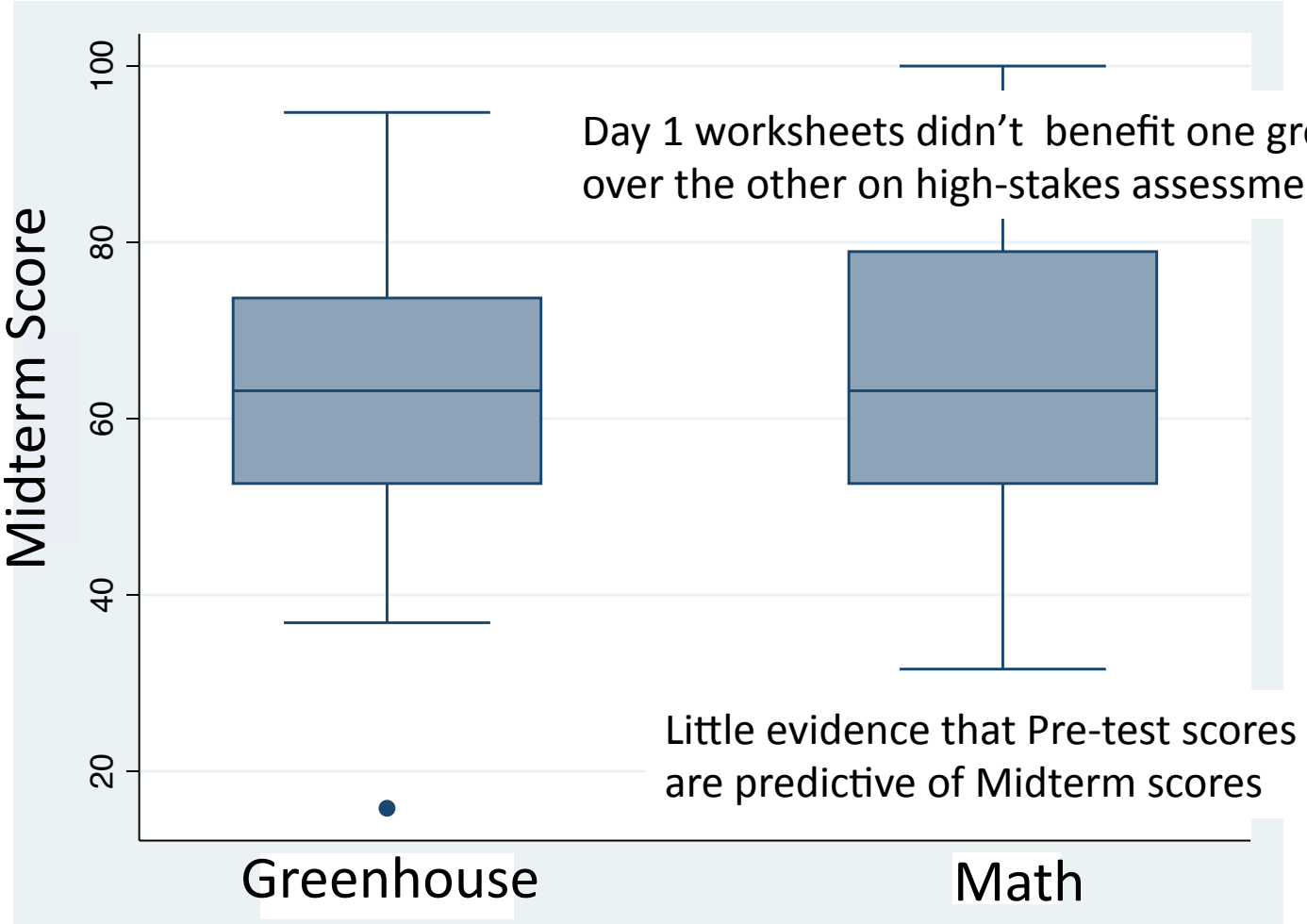


“Greenhouse” group averages higher on the Conceptual pre-test Qs than “Math” group



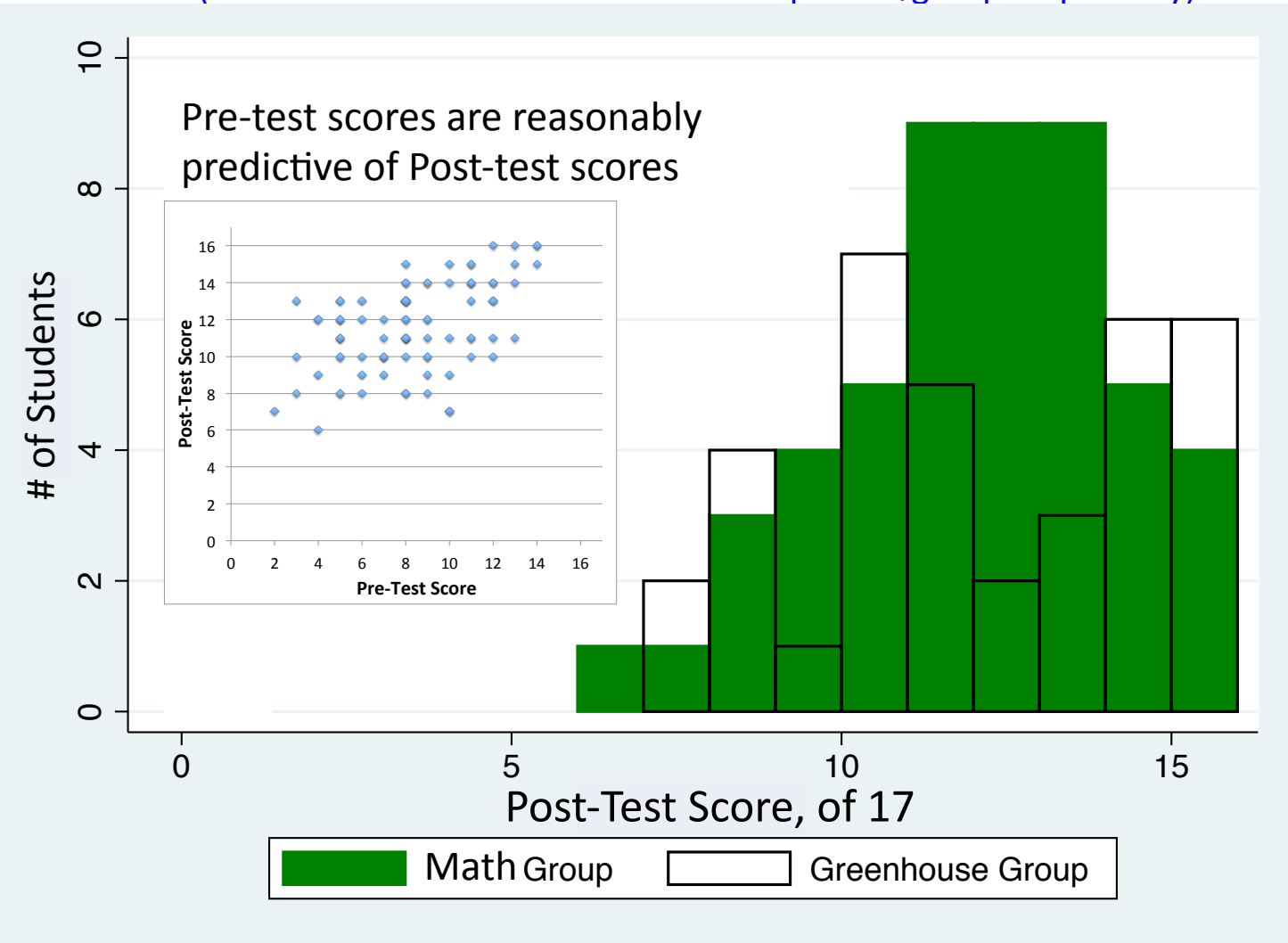
The two groups scored the same on the math-heavy midterm

("Math" group slightly higher - not statistically significant; p = 0.56)



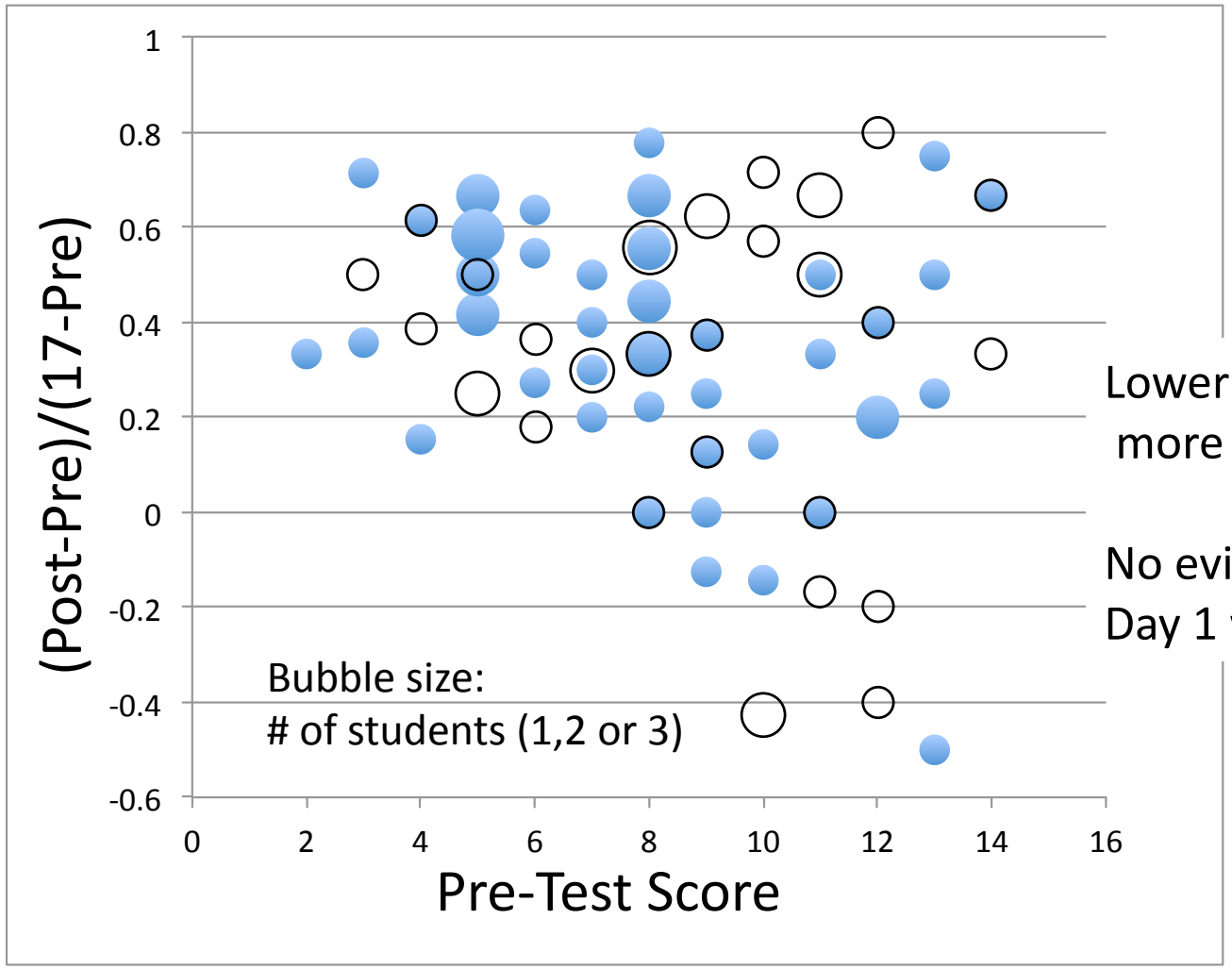
“Math” and “Greenhouse” groups average the same on the Post-test Qs ($p = 0.63$)

(and the same on the Math and Conceptual Q groups separately)



The two groups make equivalent Pre-Post learning gains (Average ~0.36)

(Lower Pre-score → generally greater growth)



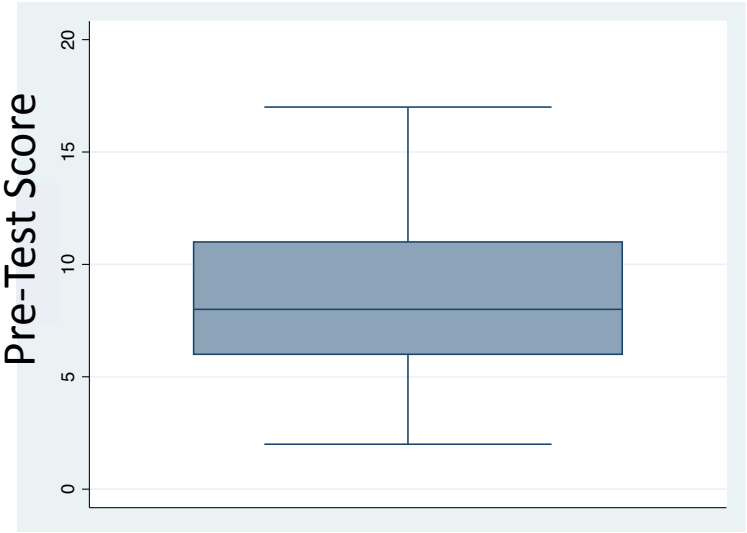
Math group

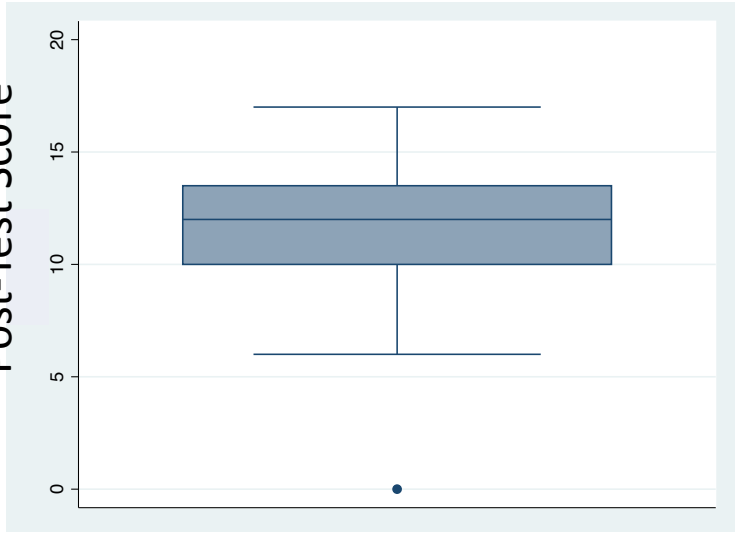
Greenhouse group

Lower Pre-test score → more positive gains

No evident effect of Day 1 worksheets

(Some good news) Overall Pre-Post Gains: Effect size ~1 standard deviation (Hedge's g = 1.08)





The class structure overall is producing strong learning gains, based on this particular pre-post assessment

Takeaways

Success of the Day 1 Intervention?

- The Day 1 math-focused worksheet did not improve students' math-related scores, neither immediately, nor later in the term, over students who did not do the Math worksheet.
- The Day 1 greenhouse-focused worksheet improved student's performance on conceptual questions immediately, but that advantage was erased by the end of the term.

Overall learning gains?

- The current class structure results in significant learning gains for students (effect size ~1)
- Performance on the Pre-test is predictive of performance on the Post-test

Who should we target for early interventions? (not sure yet)

- Engagement indicators (e.g. clickers, pre-class quizzes, assignments, none yet examined) may help identify students who would benefit from early interventions, better than pre-test scores.