

Drawing Attention: Do Sketching and Problem-Solving Frameworks Support Student Thinking?

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Problem-Solving Scaffolds

- Educators and curriculum designers include instructional scaffolds to support students' problem-solving

We investigate two:

- Sketching:** representing relations visually
 - More beneficial than summarizing a science text^{1,2}
 - May lure students into a false sense of understanding³
- Problem-solving frameworks:** guide students through a series of steps
 - Especially effective in structuring problem solving⁴
 - May result in less adaptive problem-solving^{5,6}

Study Design

4 conditions, between-subjects, randomized within-class

Control	Sketch
Framework	Framework + Sketch

Sketch Prompt

Be sure to draw a sketch to support your thinking!

Problem-Solving Framework: RIDEA

- Represent the problem in terms of symbols and figures
- Interpret the problem by identifying applicable concepts and principles
- Develop a plan for solving the problem
- Evaluate your answer
- Assess your answer

Participants and Setting

- 66 undergraduate students
- Calculus-based Electricity & Magnetism course
- 2 optics problems completed during recitation section

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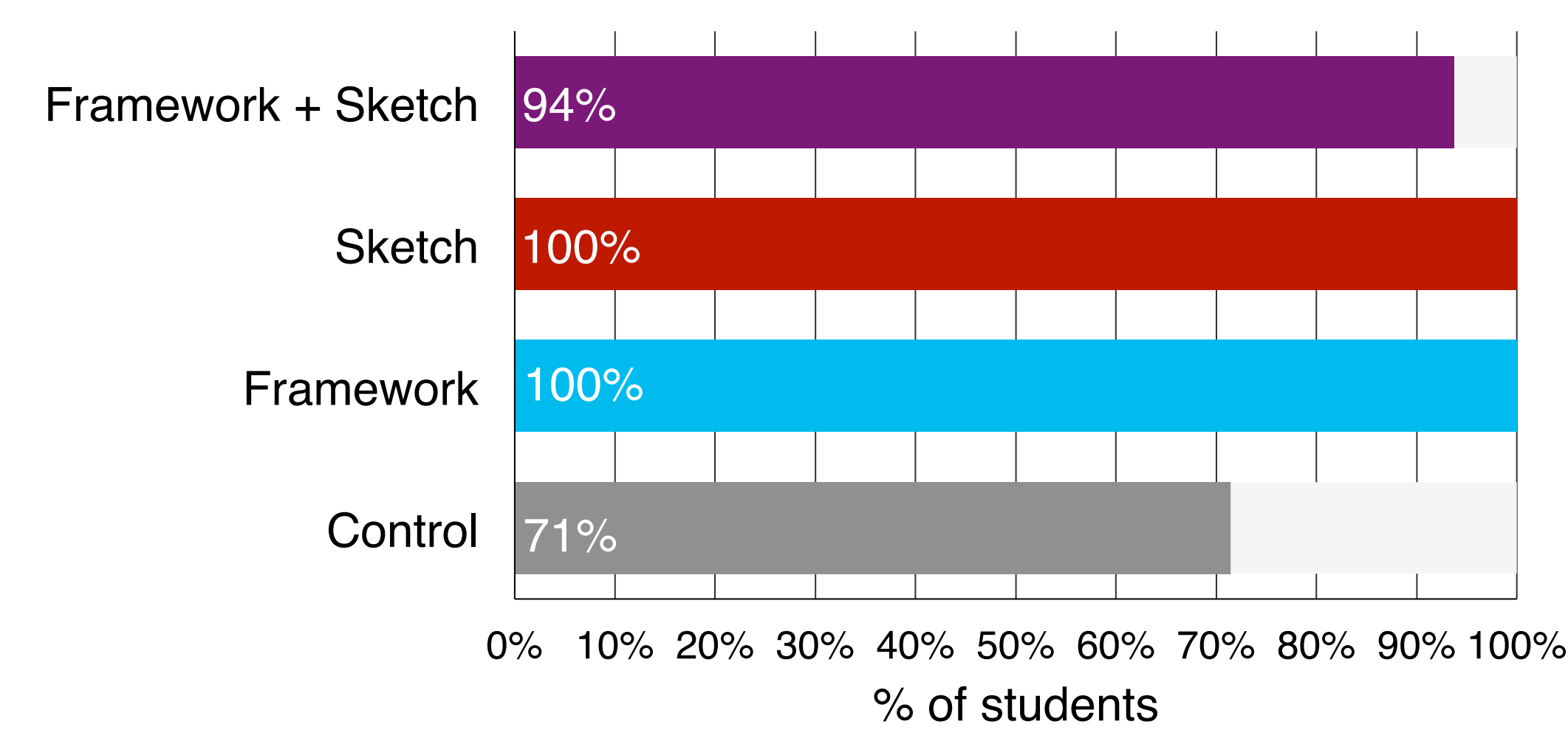
Do scaffolds help students avoid getting stuck?

YES! Scaffolds → fewer incomplete answers
 ($X^2 = 11.81, p < .01$)

Problem 1:

A bright object and a viewing screen are separated by a distance of 86.0cm. At what location between the object and the screen should a lens of focal length 16.0cm be placed in order to produce a sharp and enlarged image on the screen?

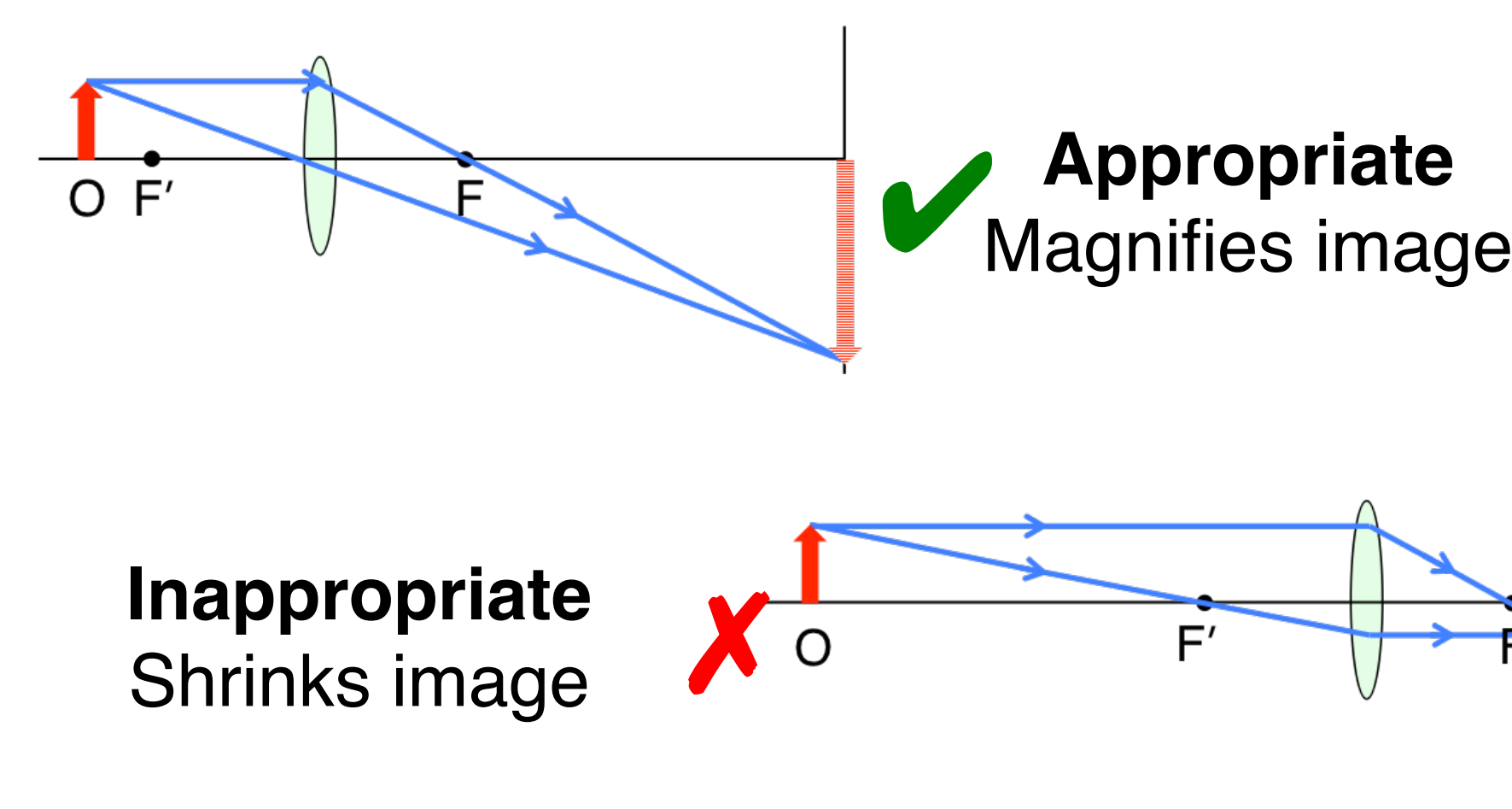
% of Students with Complete Solutions



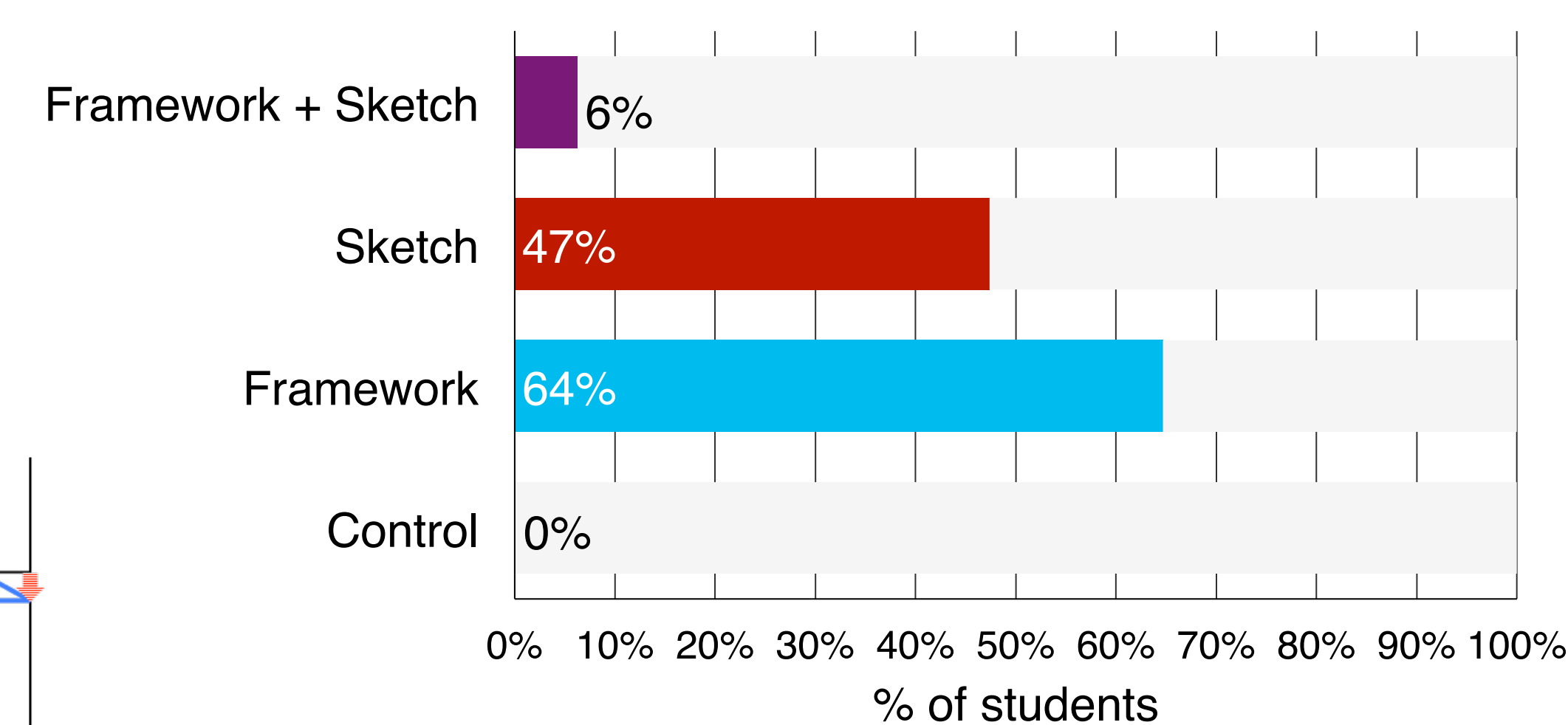
Do scaffolds affect sense making?

YES! Scaffolds → fewer nonsensical answers
 ($X^2 = 21.95, p < .01$)

Two mathematically accurate answers:



% of Students Giving One Answer

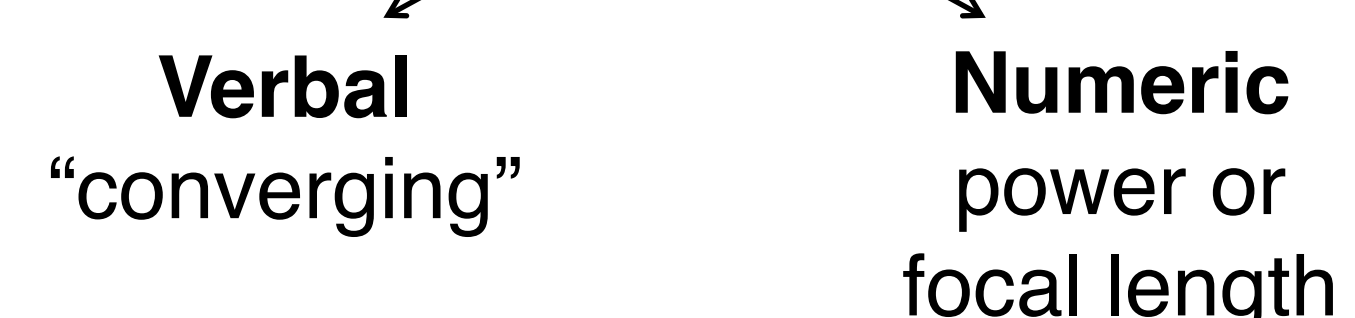


Do scaffolds affect precision?

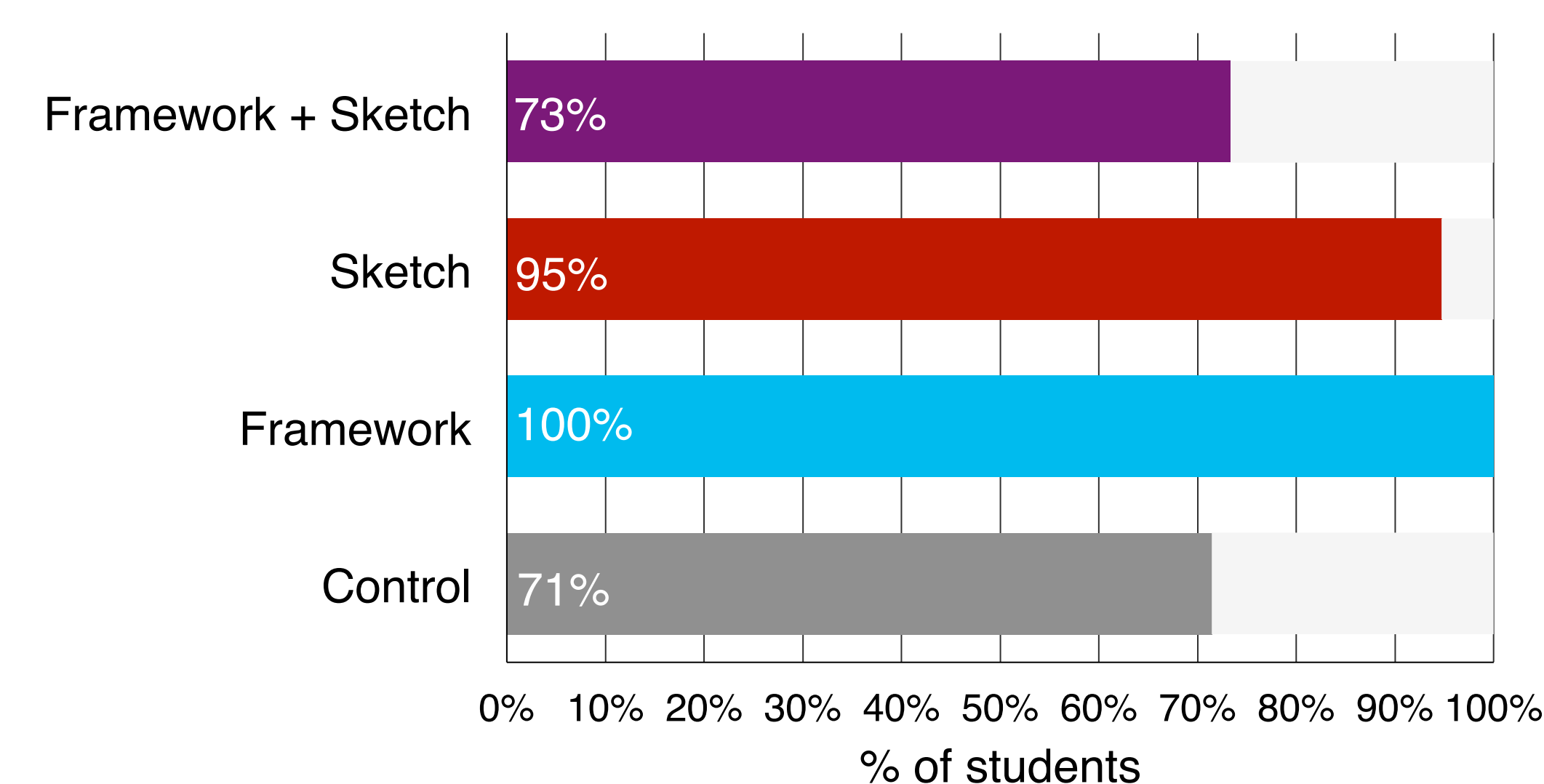
YES! Scaffolds → fewer imprecise answers
 ($X^2 = 8.52, p = .03$)

Problem 2:

It is desired to magnify reading material by a factor of 2.53 when a book is placed 9.0cm behind a lens. What lens is needed?



% Of Students Giving Numeric Answers



Conclusions

- Sketching prompts and problem-solving frameworks support productive critical thinking
 - Especially useful for avoiding incomplete solutions
 - Frameworks and sketching help people get started
- Important to assess precision and sense making
 - Scaffolds helped both
 - Can show misconceptions or error patterns above and beyond correctness measures
- Does Framework + Sketch really hinder performance?
 - Did not find evidence of productive, additive effects of the combination of both prompts
 - Following both scaffolds together may be overwhelming and prescriptive

Future Directions

- Replicate
 - More participants
 - Additional problems on other physics topics
- More measures
 - GPA or course grades
 - Conceptual Survey of Electricity & Magnetism or Brief Electricity & Magnetism Assessment
- Investigate more about scaffolds
 - When:* Introducing new material vs. reviewing topics?
 - Why:* Clarify existing ideas or reveal misconceptions?
 - For whom:* Especially for high or low prior knowledge?

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