The Specificity Effect: Implications for Transfer in Physics Learning

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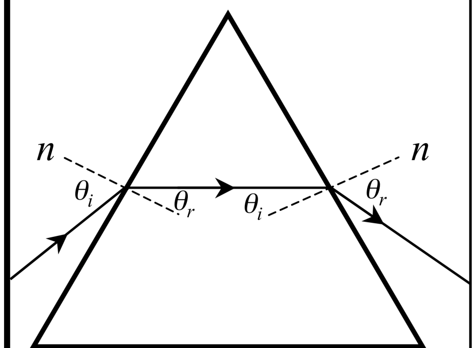
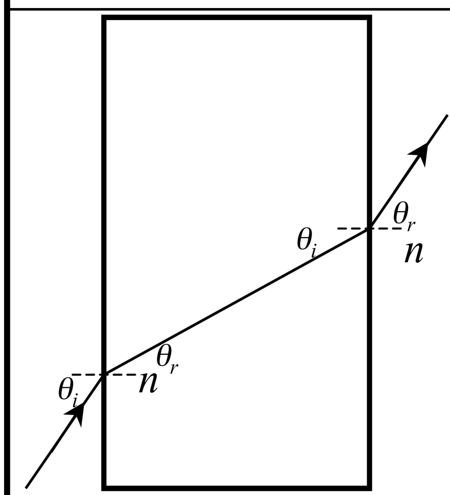
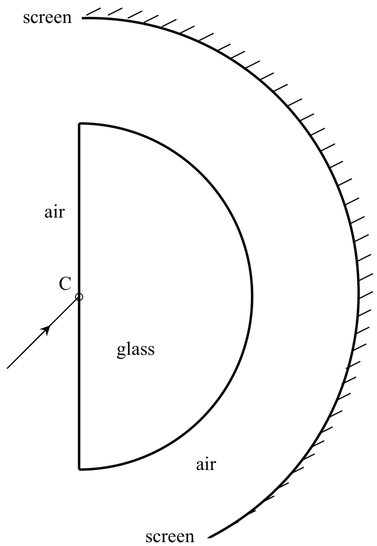
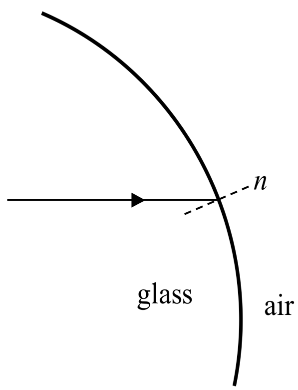
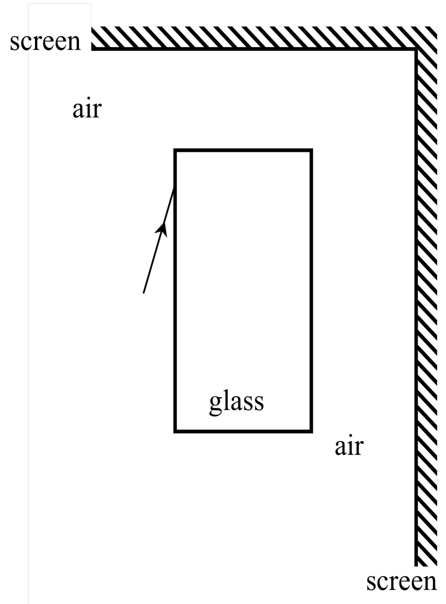
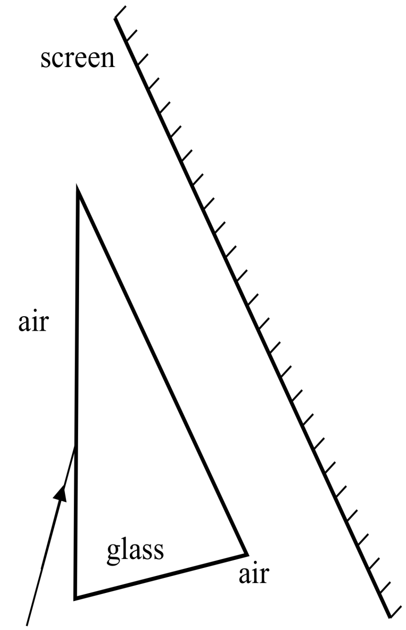
What is the Specificity Effect?

- When we learn principled knowledge, it becomes bound to the content in which it is instantiated (Ross; 1984, 1987).
- This is NOT an expert/novice difference (Blessing & Ross, 1996).
- In other words…(Chi et al., 1981) didn't get the whole picture.

Design of Study 1.

Training	Test Q.1	Test Q.2	Test Q.3
 	 	 Test Q.4	

Subjects

- 31 Physics 101 students at UIUC
- Algebra-based physics course for life-science majors and pre-meds.
- 15 trained with triangle-prism example, 16 trained with rectangle-prism example.

Data Overview

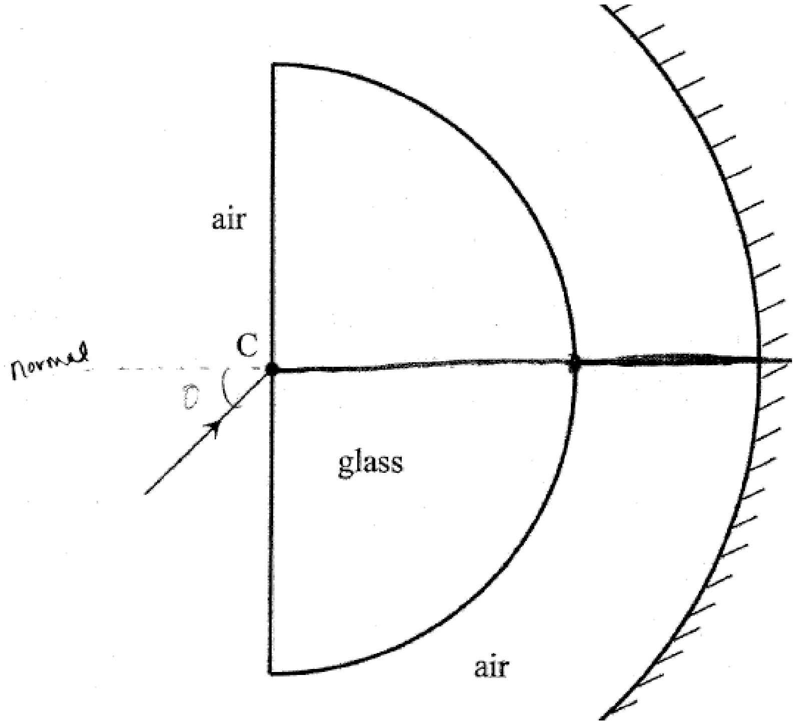
Training example	Triangle	Rectangle
Number of subjects	15	16
Number who could instantiate principle (Q4)	7	11
Number who were (basically) clueless	8	5

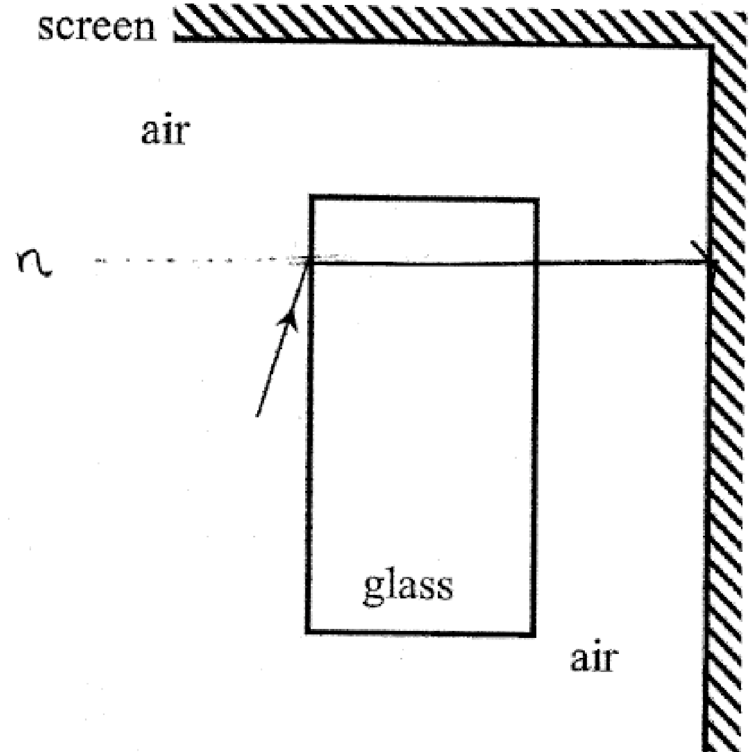
Summary

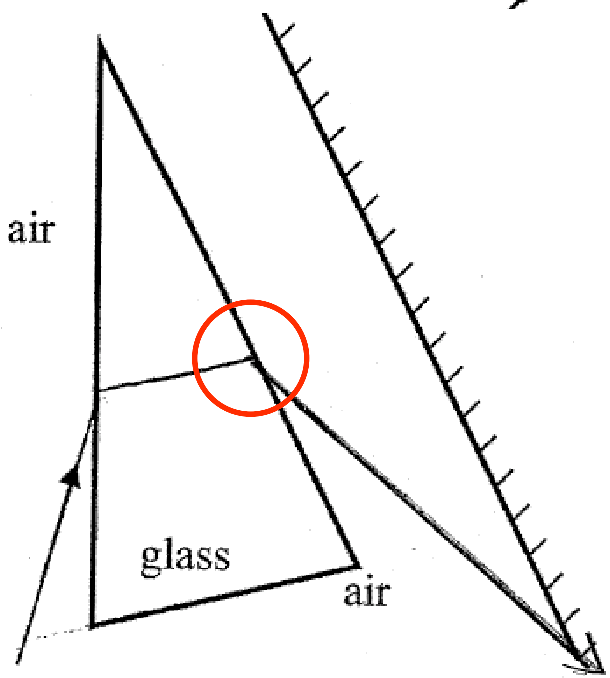
Out of those subjects who demonstrated at least some reliable ability to instantiate the refraction principle (n=18)

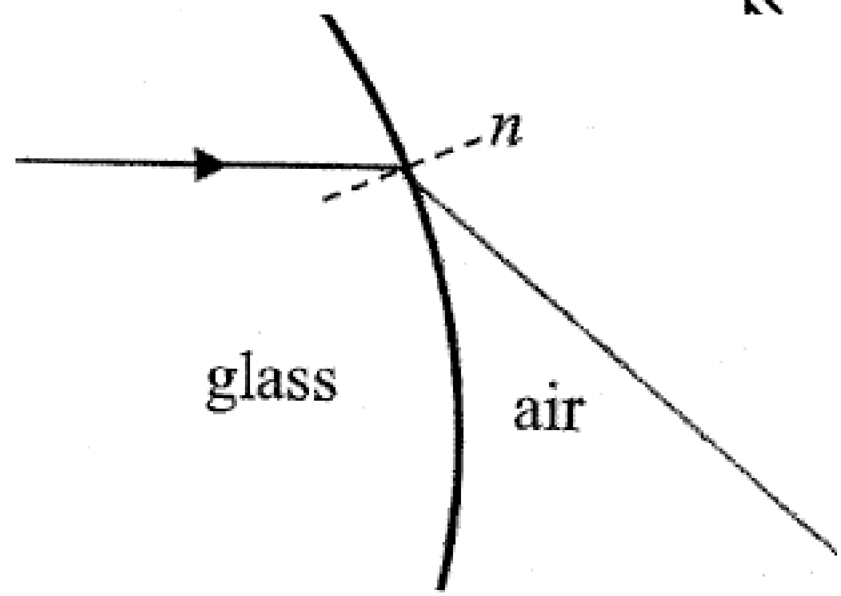
Example biased subjects	12/18	67%
Unbiased subjects	4/18	22%
Subjects who didn’t fit the pattern	2/18	11%

003: Triangle-Trained Subject

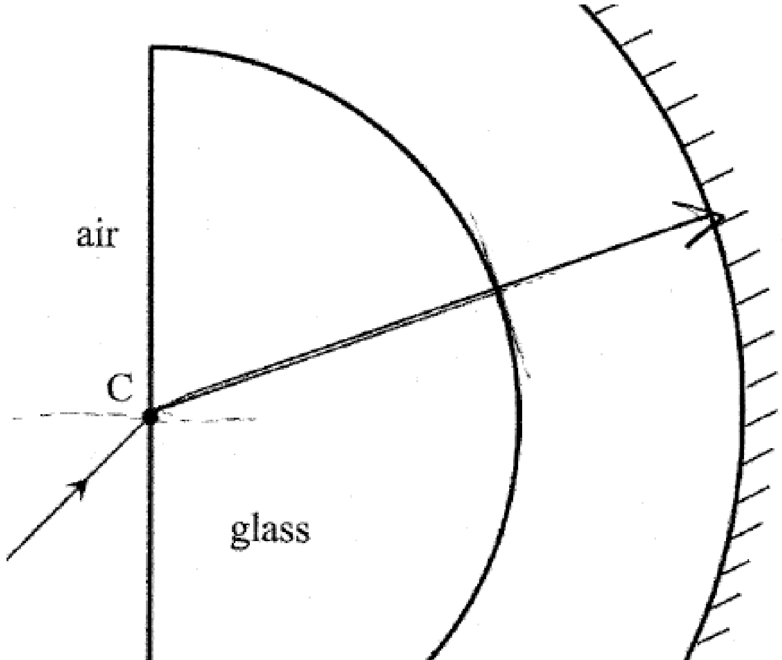


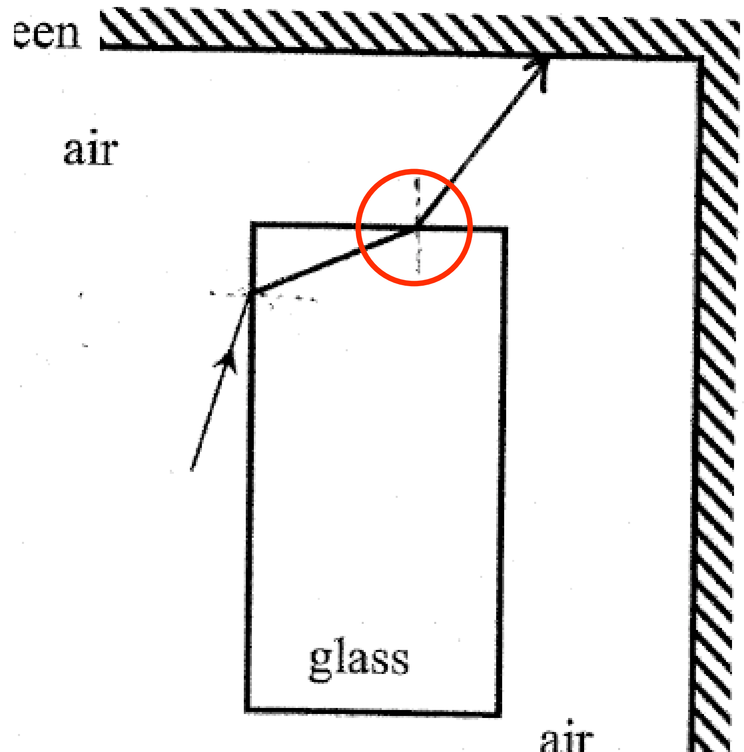


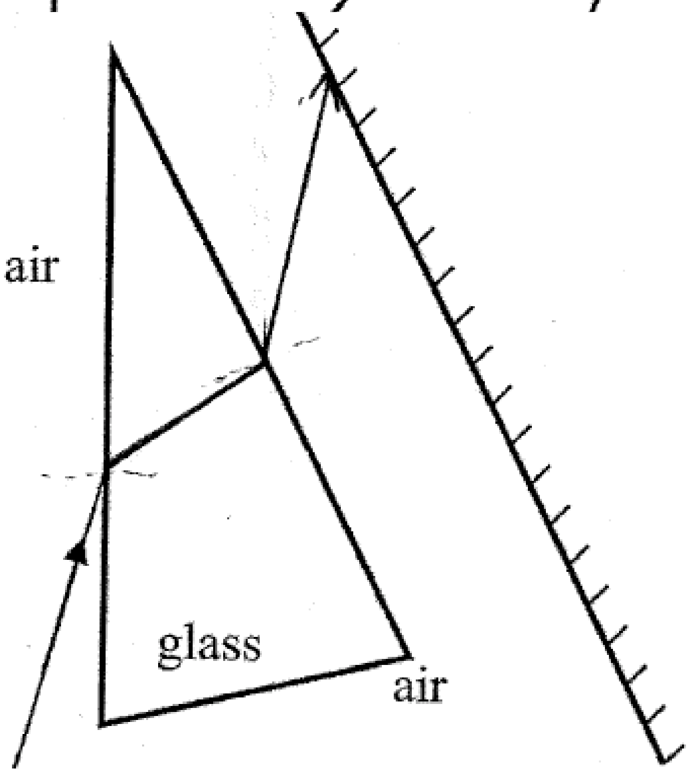


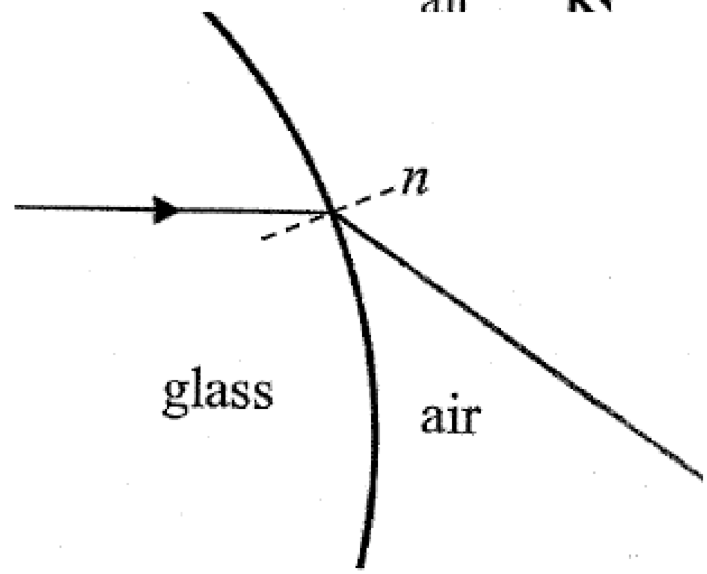


207: Rectangle-Trained Subject

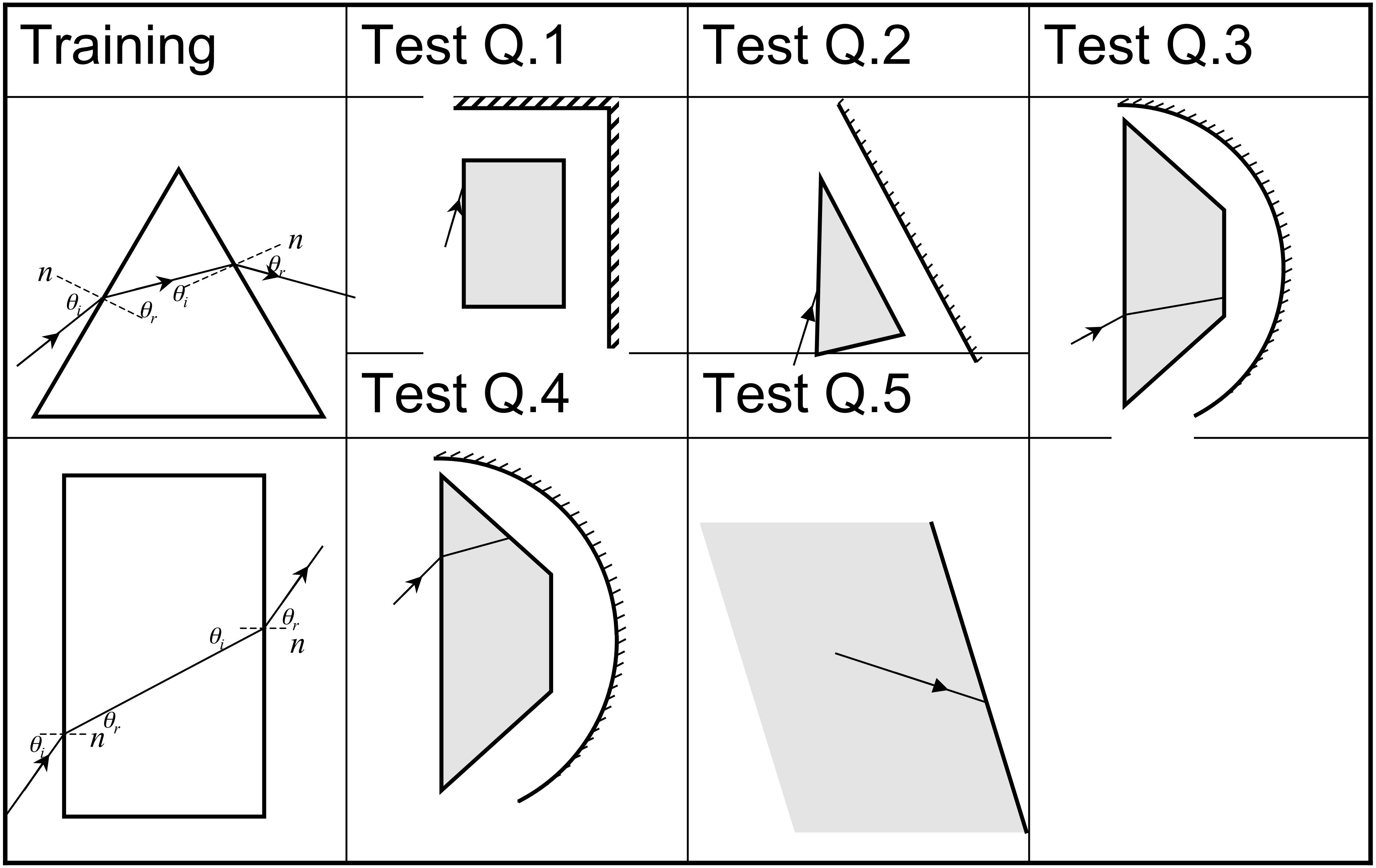








Design of Study 2.



Subjects

- 48 Physics 211 students at UIUC
- Calculus-based physics course for engineering majors.
- UIUC's engineering school is the most selective in the US.
- 25 trained with triangle-prism example, 23 trained with rectangle-prism example.

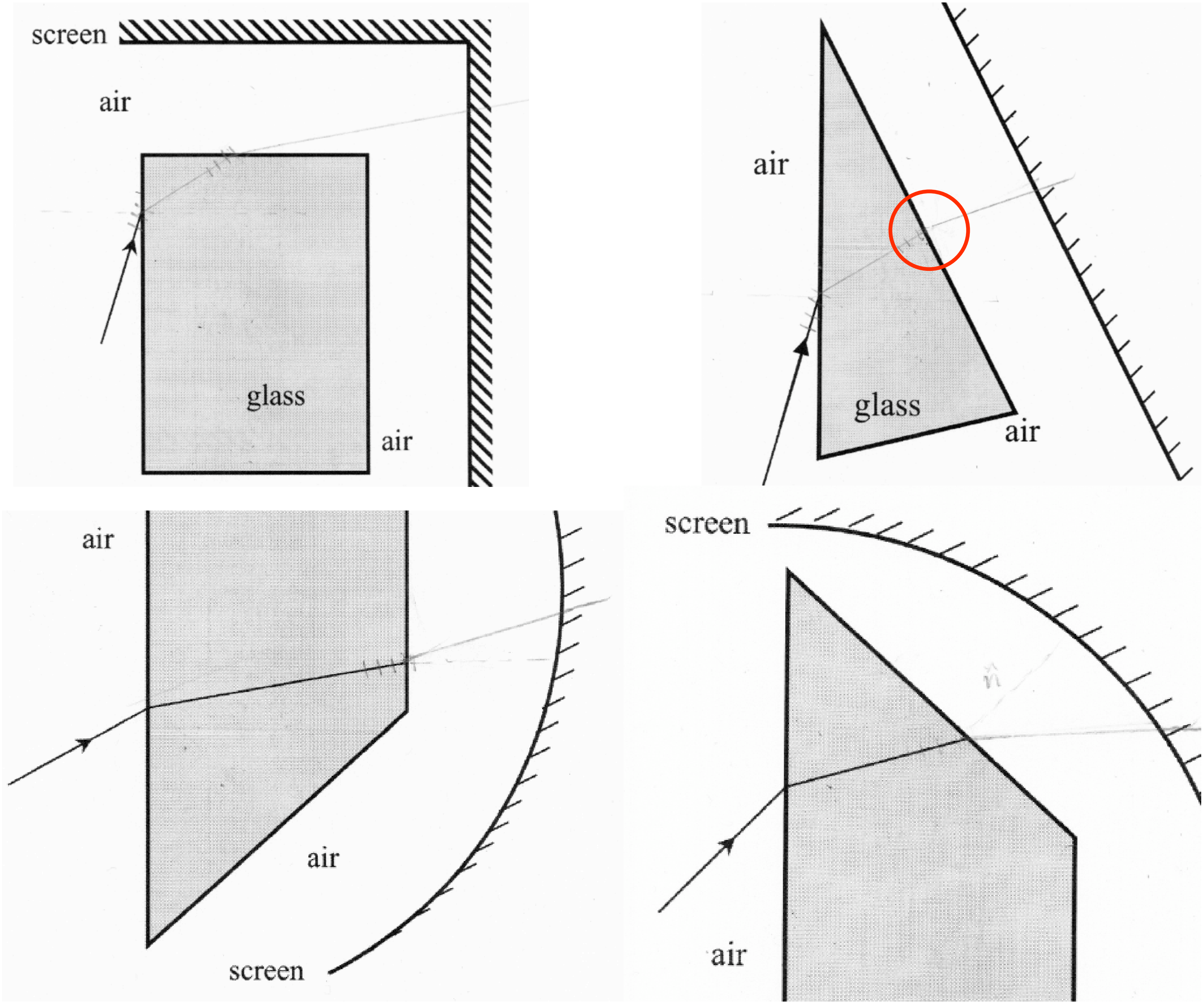
Data Overview

Training example	Triangle	Rectangle
Number of subjects	25	23
Number who could instantiate principle (Q5)	22	22
Number who were (basically) clueless	3	1

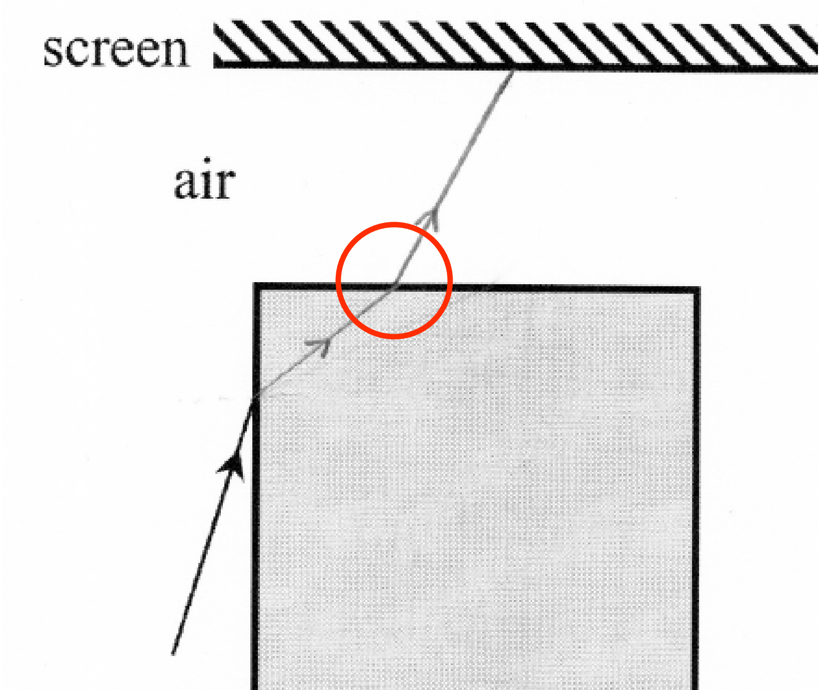
Summary

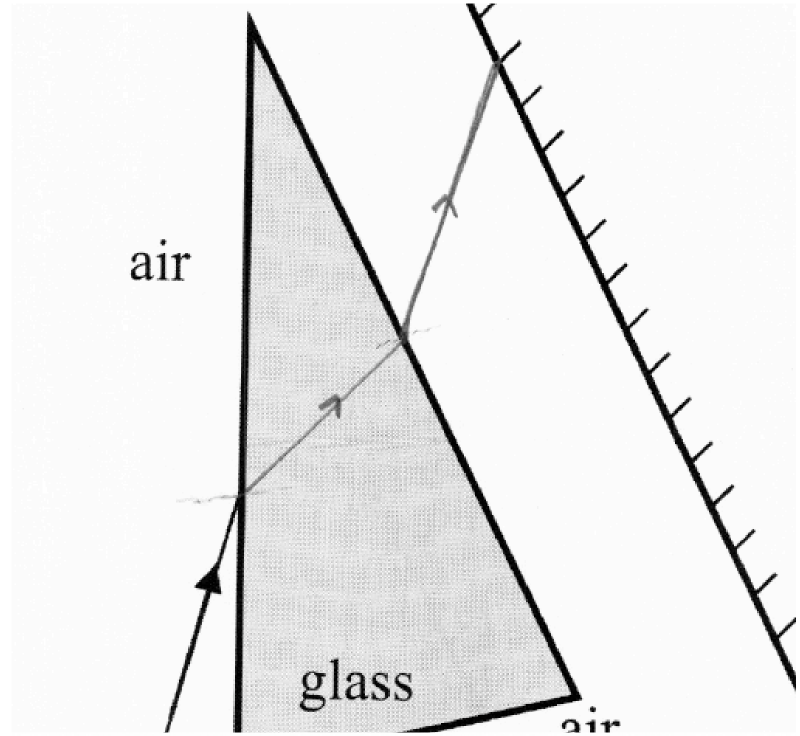
- If we set a stringent criterion (unequivocal evidence of principled reasoning) for specificity, 8/22 triangle-trained & 8/22 rectangle-trained subjects show clear example bias (36%).
- If we relax the "unequivocal evidence" criterion, 8/22 triangle-trained & 16/22 rectangle-trained subjects show clear example bias (total, 55%).

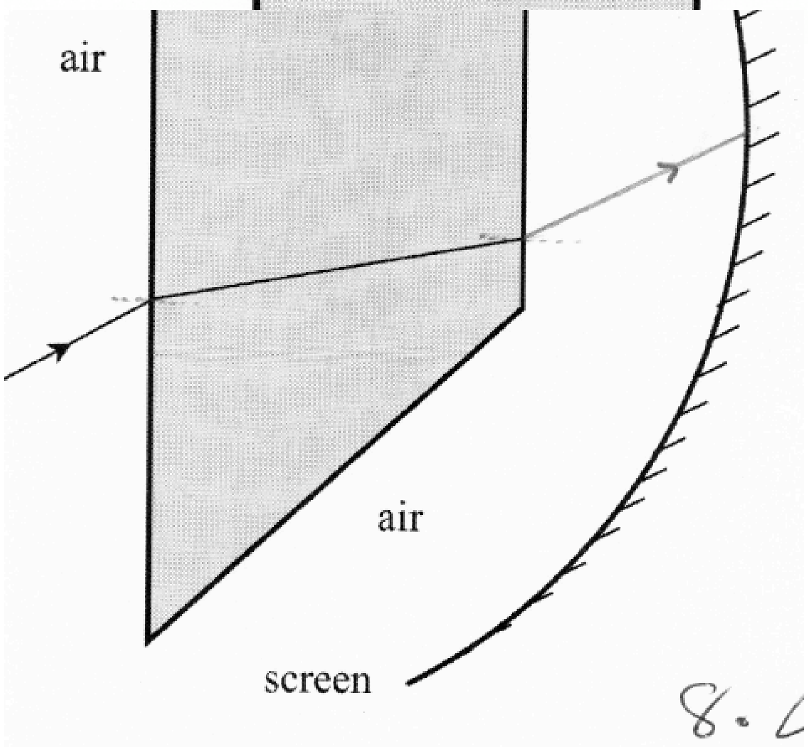
C13: Triangle-Trained Subject

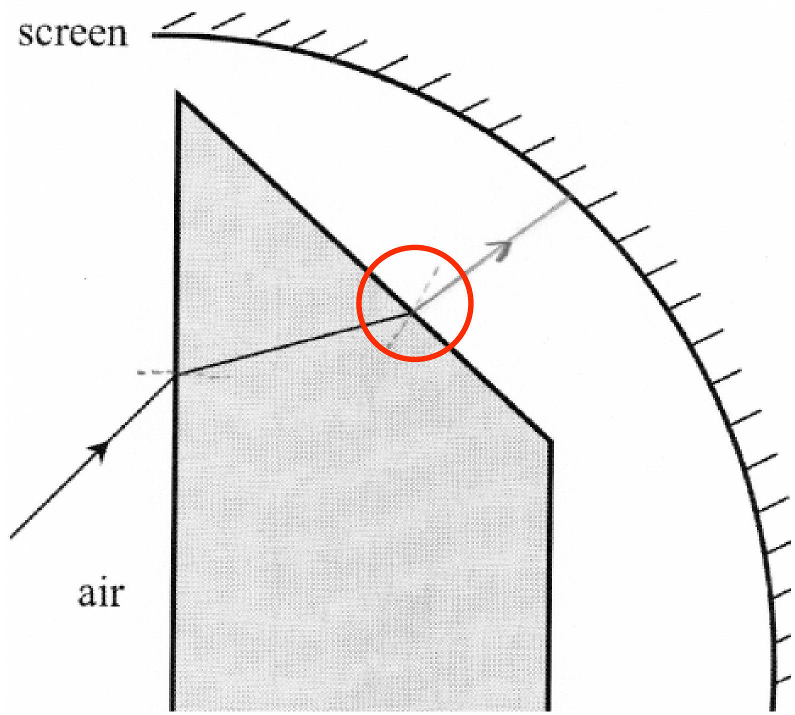


B13: Rectangle-Trained Subject

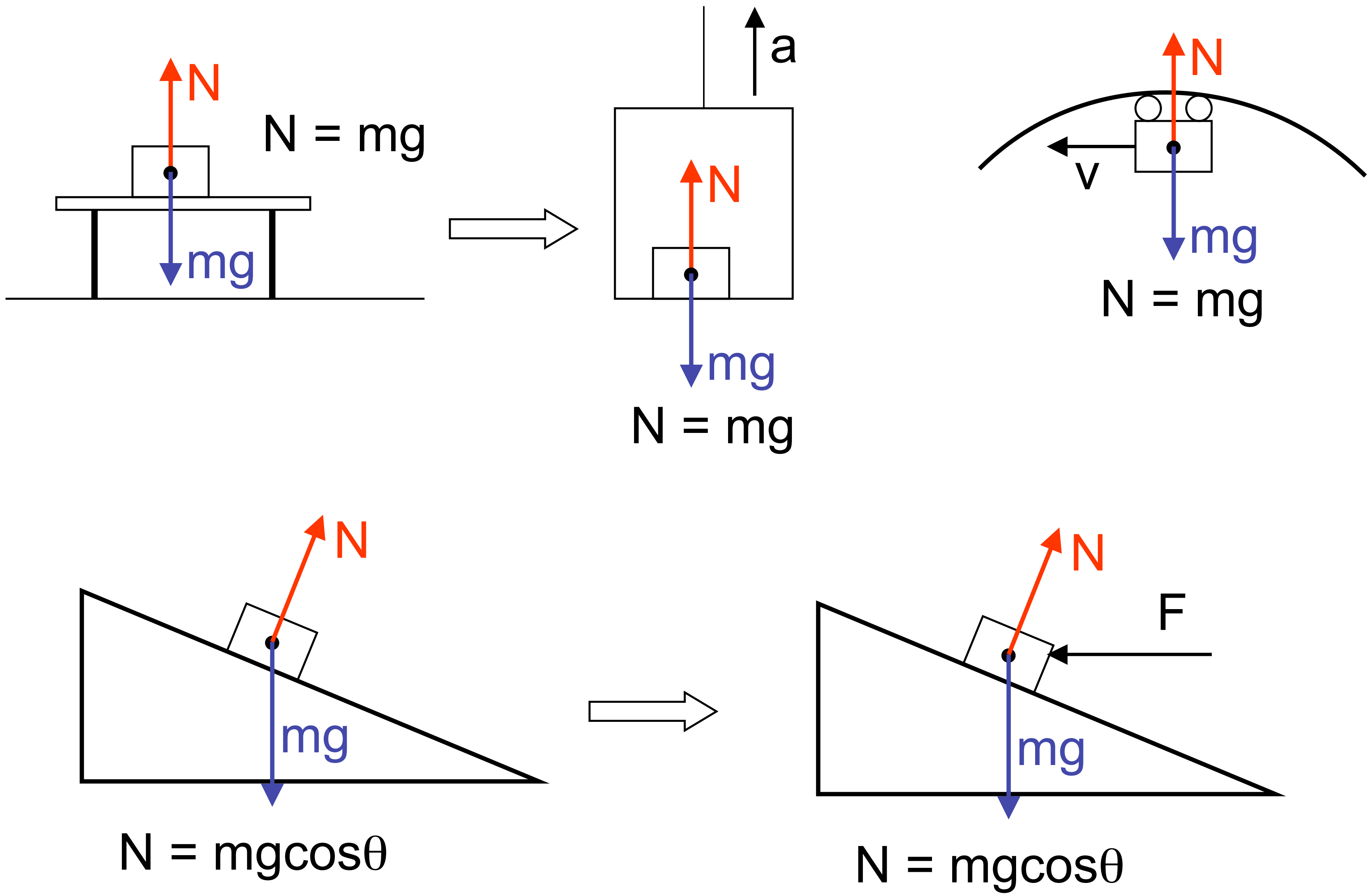








We Think This is Ubiquitous



Experts Experience it too…

(Eugene Torigoe): A block of mass *m* on a frictionless horizontal surface is initially at rest. A constant horizontal force is applied to the block for *t* seconds, and the block reaches a final momentum *P*. How far did the block travel during this time period?

(a) $d = \frac{P * t}{4m}$

(b) $d = \frac{P * t}{2m}$

(c) $d = \frac{P * t}{m}$

(d) $d = \frac{2P * t}{m}$

(e) $d = \frac{4P * t}{m}$

$$\Delta\vec{p} = \vec{F}\Delta t \longrightarrow \vec{a} = \vec{F}/m \longrightarrow d = \frac{1}{2}a\Delta t^2$$

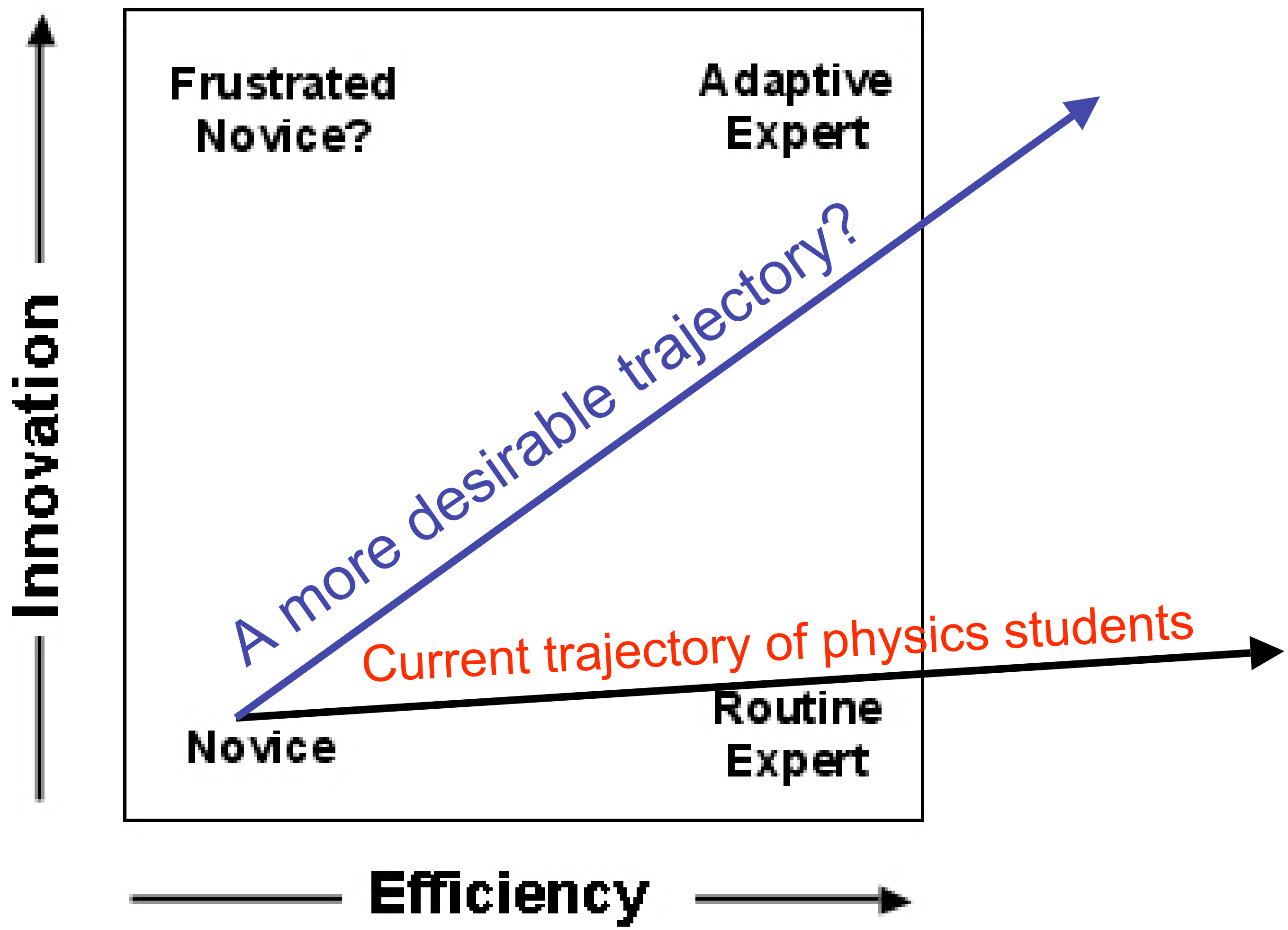
$$\hookrightarrow d = v_{\text{avg}}\Delta t = \frac{1}{2}\frac{P}{m}t$$

What Does it All Mean?

- Should we use multiple examples?
- Yes, but may result in multiple content-specific instantiations.
- Should we use contrasting cases?
- Yes, but won’t work without active & deep reflection.
- How does this affect assessment?
- How does this affect what we want students to learn?

Adaptive vs. Routine Expertise

Schwartz, Bransford & Sears (2005)



Two Views of Transfer

- Transfer of knowledge from one situation to a new/novel situation.
- Transfer is hard, generally characterized by failures to transfer.
- The ability to use what your experiences and abilities to learn about a new situation. (- "Preparation for Future Learning" - Bransford & Schwartz, 1999).
- Transfer is ubiquitous.

My Ultimate Teaching Goal

- Prepare students for future learning.

- How do physicists learn about the world?
  - We would like to engage students in a similar process.

- Students should be learning how to learn like a physicist.