CLASSROOM DEMONSTRATIONS: LEARNING TOOLS OR ENTERTAINMENT?

Catherine H. Crouch
Swarthmore College

Adam Fagen, J. Paul Callan, and Eric Mazur
Harvard University

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Goals of demonstrations

- Educate
- Motivate

Are these goals met?

Outline

- Background
- Study: vary mode of presentation
- Results: impact on student understanding
- Conclusions

Background

- Psychology research: people remember what they expect to see

- Education research: students may not learn much from demonstrations

Background

Research on learning from demonstrations:

- **Ability to predict outcome improves somewhat by seeing demonstration**
- **Understanding of concepts does not!**

P. Kraus, *Ph. D. thesis*, University of Washington, 1997

Background

Research on learning from demonstrations:

- Sequences of interactive demonstration-based activities produce learning gains
- Replaces one hour of lecture per week

D. Sokoloff and R. Thornton, *Phys. Teach.* 35, 340 (1997)

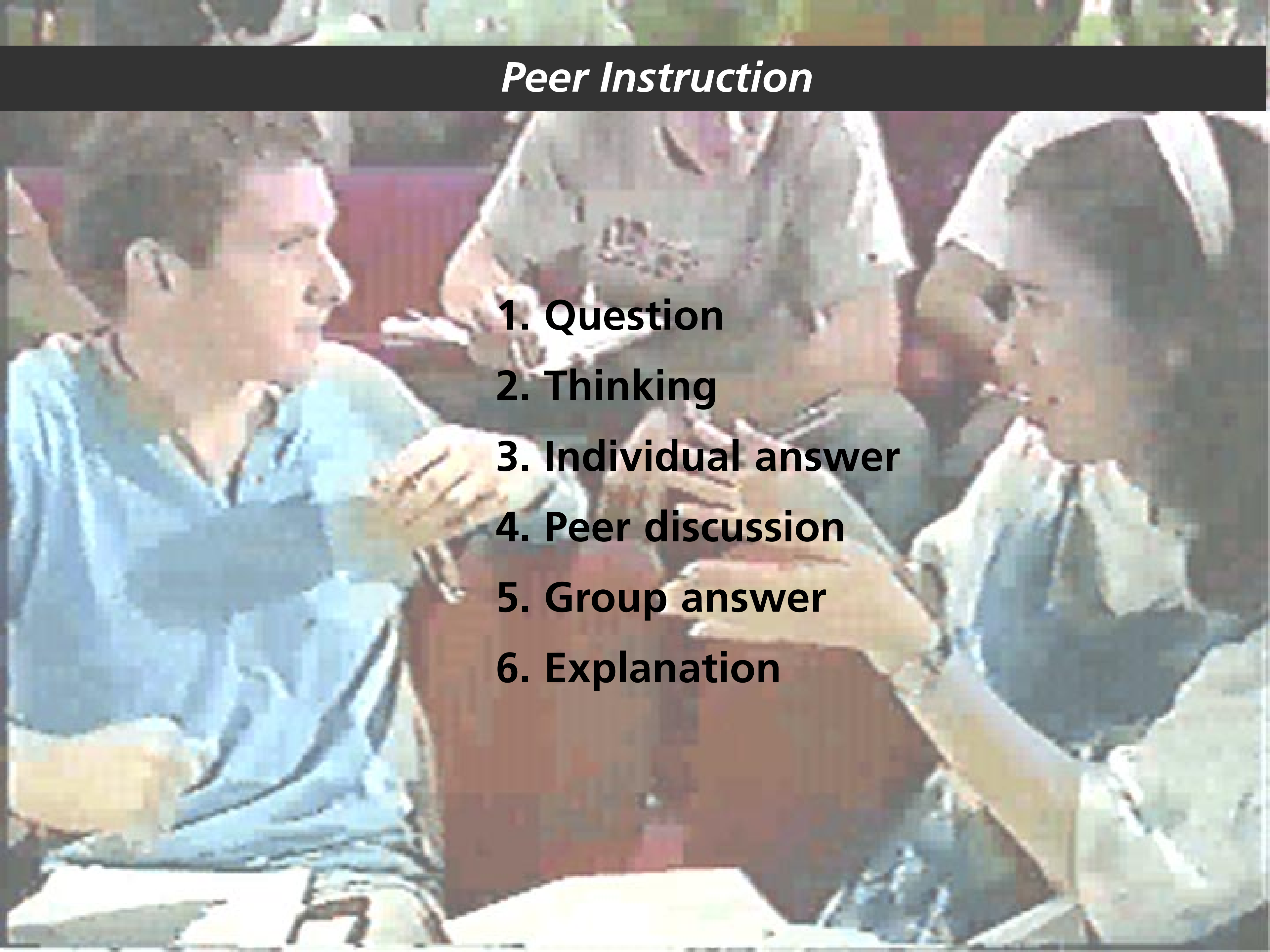
Can demonstrations be more educational?

How else can demonstrations be improved?

Can demonstrations be more educational?

- **Peer Instruction: increase engagement by interspersing lectures with questions**

Peer Instruction



1. Question
2. Thinking
3. Individual answer
4. Peer discussion
5. Group answer
6. Explanation

Can demonstrations be more educational?

- **Peer Instruction: increase engagement by interspersing lectures with questions**

- **Demonstrated improvement in student understanding of lecture material**

Catherine H. Crouch and Eric Mazur, *Am. J. Phys.* 69, 970 (2001)

Can demonstrations be more educational?

- **Get students thinking:**

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- **Get students thinking: ask for predictions**

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- Create opportunities to explain and ask: students record and discuss predictions

Can demonstrations be more educational?

- **Get students thinking: ask for predictions**
- **Create opportunities to explain and ask: students record and discuss predictions**
- **Confront and resolve: students rethink prediction after observation**

Research strategy

7 demonstrations presented to 7 sections ($N \approx 15$) of introductory physics class in one of 4 'modes':

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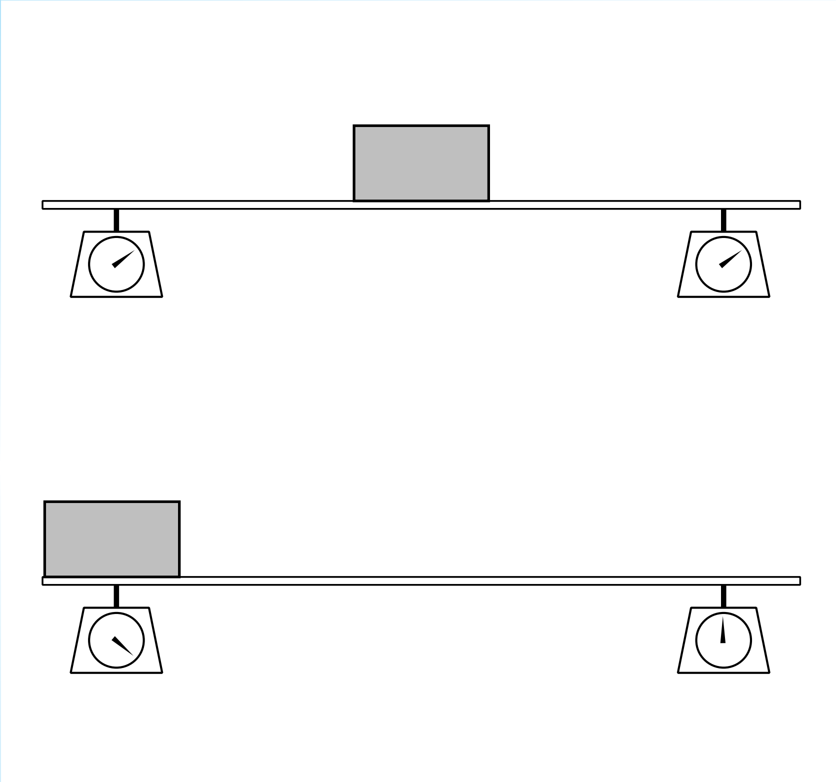
7 demonstrations presented to 7 sections ($N \approx$ 15) of introductory physics class in one of 4 'modes':

- **demonstration not shown**
- **traditional presentation**
- **students predict before demonstration**
- **students predict, compare, and discuss**

Sample demonstration



Sample demonstration

A plank of negligible mass is supported at its two ends by platform scales. When a block of metal is placed at the center of the plank, halfway between the scales, the scales have the same reading x. If the metal block is now placed over the right-hand scale, the two scale readings are:

1. right scale = x, left scale = x
2. right scale = x, left scale = 0
3. right scale = 0, left scale = x
4. right scale = 2 x, left scale = 0
5. right scale = 0, left scale = 2 x
6. right scale = 1.5 x, left scale = 0.5 x
7. right scale = 0.5 x, left scale = 1.5 x
8. none of the above

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1. What are the two scale readings now? Why?

2. Record your observation of the demonstration.

3. Compare your prediction (1) to your observation (2). Do they agree?

__ Completely __ Mostly __ Somewhat __ Not at all

4. After discussing your prediction and the demonstration with your neighbors, record why your prediction and the reasoning behind it were correct or incorrect (use the back of this sheet if you need more room).

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DISCUSSION

4. After discussing your prediction and the demonstration with your neighbors, record why your prediction and the reasoning behind it were correct or incorrect (use the back of this sheet if you need more room).

Research strategy

7 demonstrations presented to 7 sections ($N \approx$ 15) of introductory physics class in one of 4 'modes'

Demonstration mode rotates from section to section

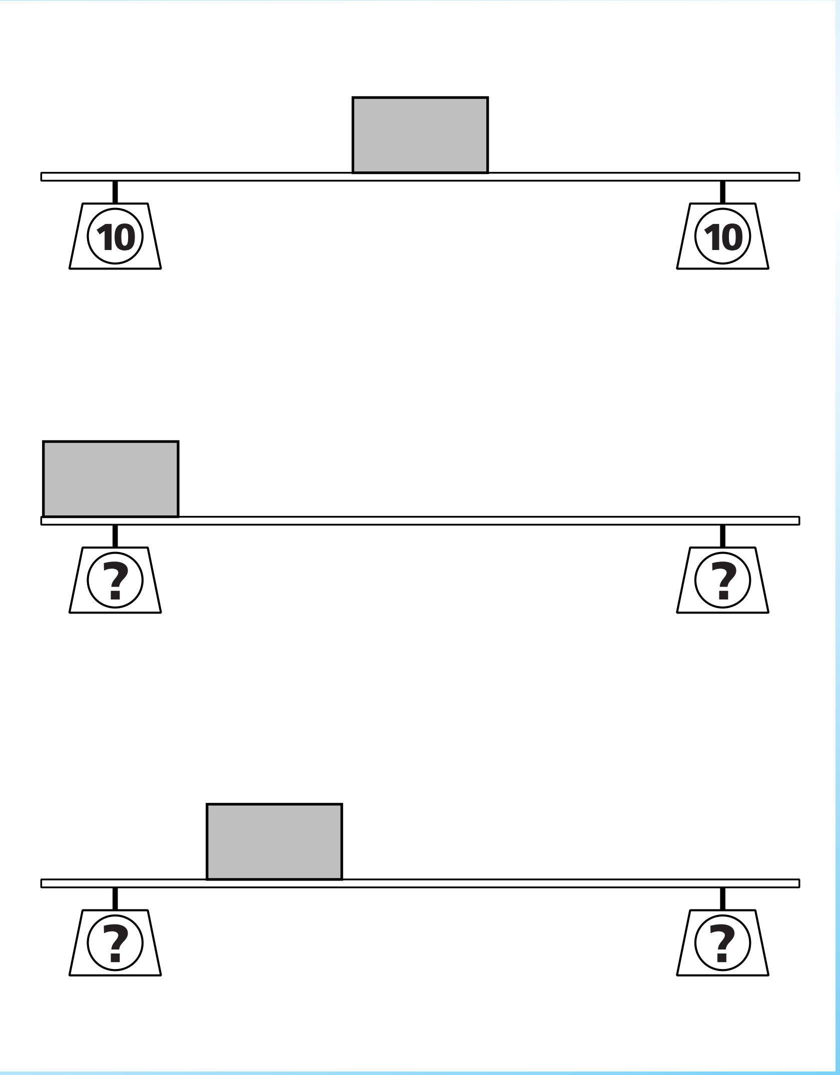
Testing

- **Web-based test**
  - **questions identical to worksheets**
  - **graded solely on effort**

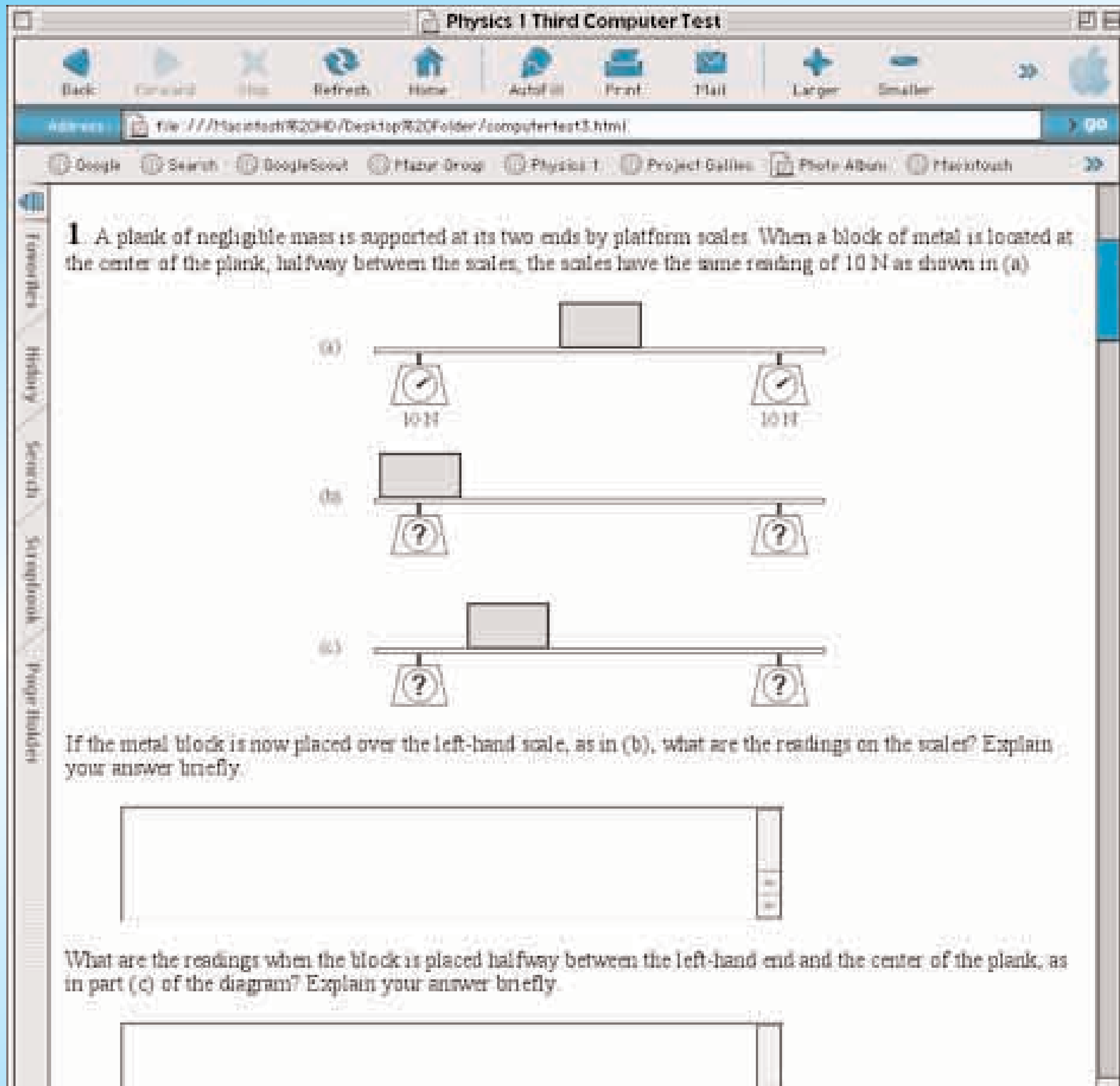
Testing

- Web-based test
    - questions identical to worksheets
    - graded solely on effort
- Analyze responses for (N = 122, 7 questions):
    - demonstration outcome
    - physical understanding

Testing



Testing



Physics 1 Third Computer Test
Back
Refresh
Home
Print
Mail
Larger
Smaller
Google
Search
Physics 1
Photo Album
1 A plank of negligible mass is supported at its two ends by platform scales. When a block of metal is located at the center of the plank, halfway between the scales, the scales have the same reading of 10 N as shown in (a).
(a)
10 N
10 N
(b)
?
?
(c)
?
?
If the metal block is now placed over the left-hand scale, as in (b), what are the readings on the scales? Explain your answer briefly.
What are the readings when the block is placed halfway between the left-hand end and the center of the plank, as in part (c) of the diagram? Explain your answer briefly.

Results: Outcome of demonstrations

	correct outcome	*P*-value	*N*
no demo	61%		
observe			
predict			
discuss			

Results: Outcome of demonstrations

	correct outcome	*P*-value	*N*
no demo	61%		
observe	70%		
predict			
discuss			

Results: Outcome of demonstrations

	correct outcome	*P*-value	*N*
no demo	61%	–	297
observe	70%	0.03	220
predict			
discuss			

Results: Outcome of demonstrations

	correct outcome	*P*-value	*N*
no demo	61%	–	297
observe	70%	0.03	220
predict	77%	< 0.001	179
discuss			

Results: Outcome of demonstrations

	correct outcome	*P*-value	*N*
no demo	61%	–	297
observe	70%	0.03	220
predict	77%	< 0.001	179
discuss	82%	< 0.0001	158

Understanding affects 'memory'!

“As demonstrated in lecture, both scales will read 10N, regardless of where the center of mass is located. The platform and the metal block form one unit that is being measured, so the scales show two evenly distributed readings, no matter where the metal block is placed along the platform.”

Understanding affects 'memory'!

- **Memory is a reconstruction at instant of recall, not like a video replay**
- **Fill in gaps in memory with information from schemas and scripts (mental models)**
- **Incorrect model can lead to inaccurate memory of scenario**

Results: Understanding

	fully correct	p-value	h-value
no demo	22%	–	–
observe	24%	0.64	0.05
predict	30%	0.04	0.18
discuss	32%	0.02	0.23

Results: Understanding

	fully correct	p-value	h-value
no demo	22%	–	–
observe	24%	0.64	0.05
predict	30%	0.04	0.18
discuss	32%	0.01	0.23

Results: Understanding

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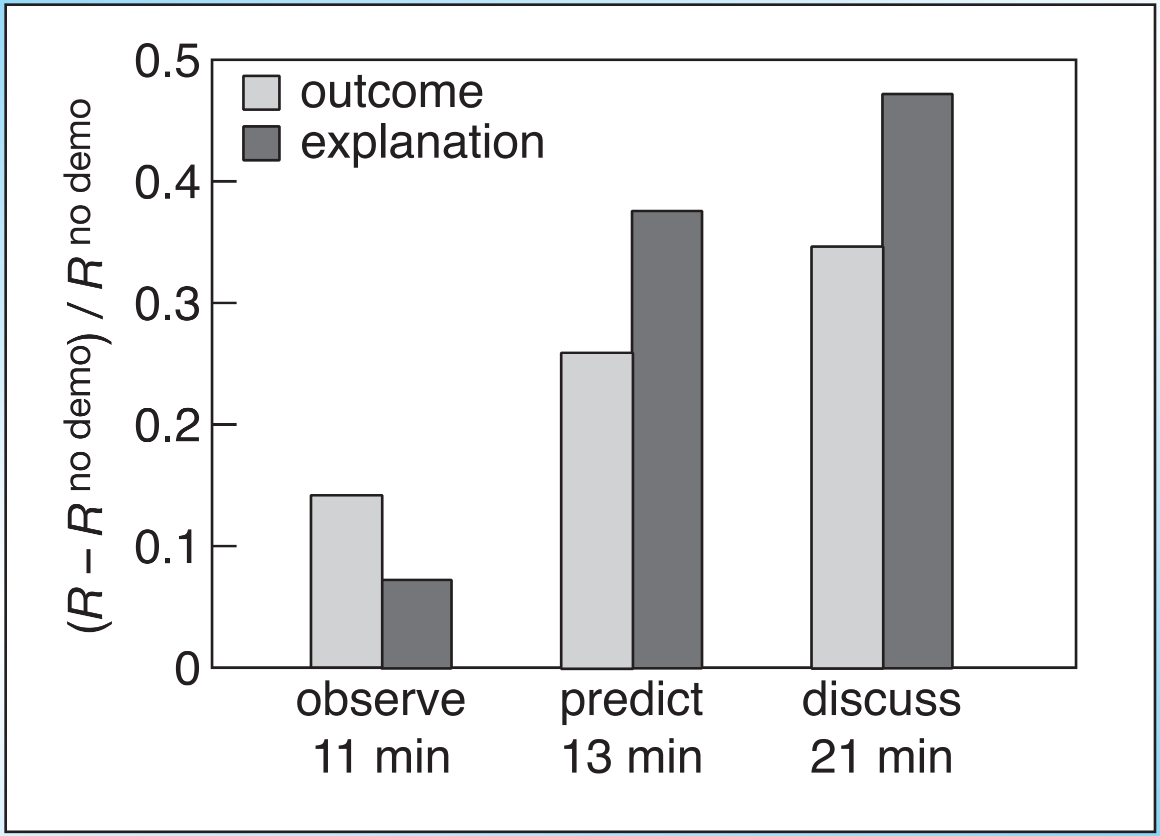
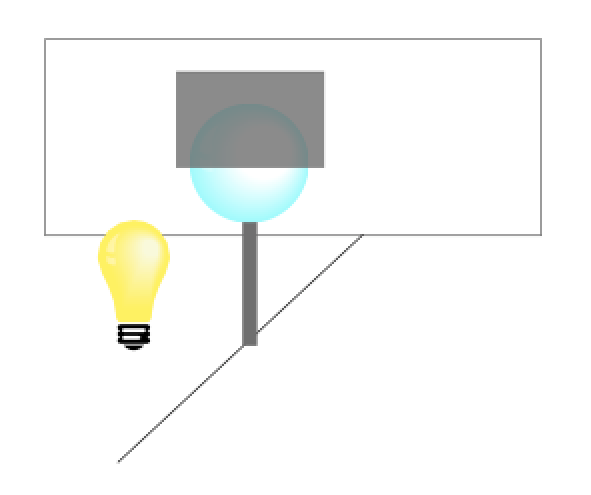
Results: Cost vs. benefit



Half-lens demonstration

A giant light bulb is placed to the left of a converging lens at a distance greater than the focal length of the lens. The image of the bulb is formed on a screen to the right of the lens. What will happen to the image if you block the top half of the lens with a card?

1. The top half of the image disappears.
2. The bottom half of the image disappears.
3. The entire image disappears.
4. The image becomes blurred.
5. The image becomes fainter.



Results: 3 ILD demos

	correct outcome	*P*-value	*N*
no demo	46%	–	162
observe	61%	0.040	41
predict	74%	0.002	31
reinforce	87%	< 0.001	30

Results: 3 ILD demos

	correct explanation	*P*-value	*N*
no demo	36%	–	164
observe	42%	0.258	41
predict	58%	0.011	31
reinforce	67%	< 0.001	30

Conclusions

- Demonstrations without active engagement produce little gain in understanding
- Predicting outcome gives significant learning gains without costing time
- Reflection and discussion produce further improvement

Collaborators: J. Paul Callan, Adam P. Fagen, Eric Mazur

Funding: National Science Foundation

Research: Students and staff of Physics 1
Demonstrations: Wolfgang Rueckner, Nils Sorensen
Discussion: Gay Stewart, Pamela Kraus, David Sokoloff

For a copy of this talk and
additional information:

http://mazur-www.harvard.edu

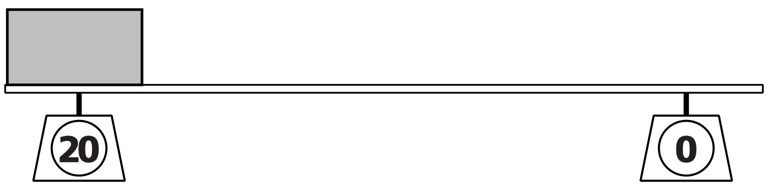
Background

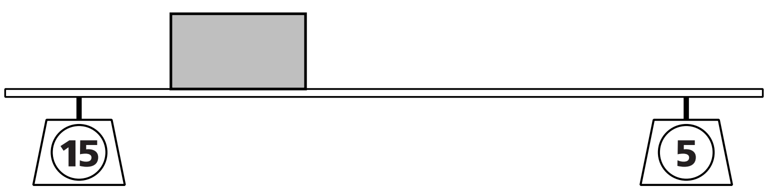
- Students don’t necessarily know what the point is!
- Traditional demonstrations rarely engage students actively
- Demonstrations are unrelated to exams

Roth *et al., J. Res. Sci. Teach.* 34, 509 (1997)

Answers

24% of students





correct (mentions torque)

Answers

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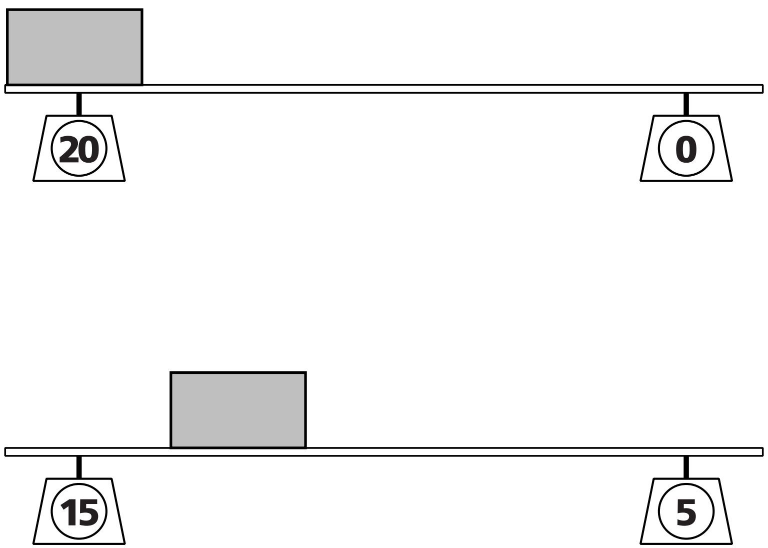
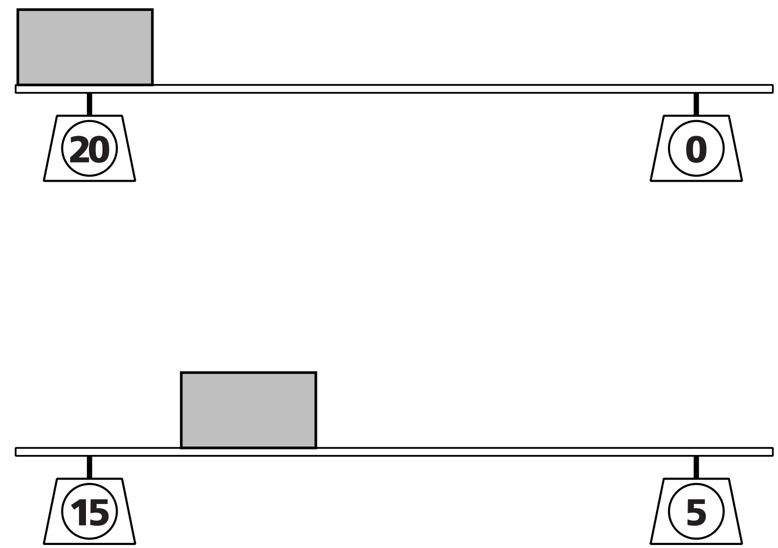


correct (mentions torque)

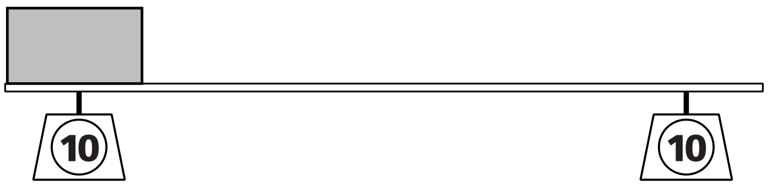
38% of students



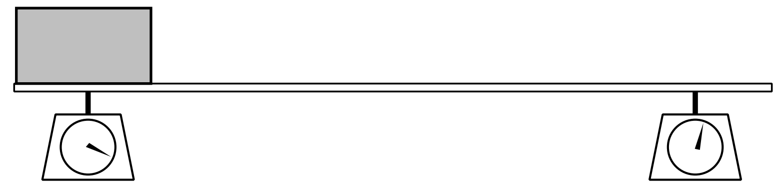
proportional reasoning

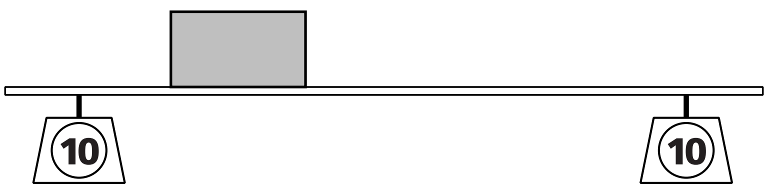
Answers

20% of students

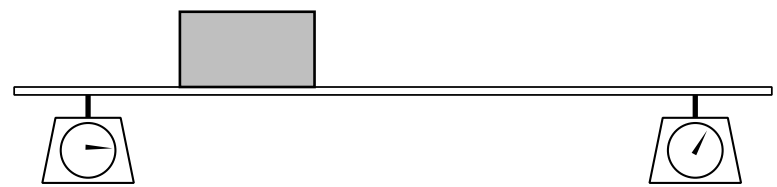


10% of students





independent of position



qualitative reasoning

6% do not balance forces
2% give other incorrect answers