# CLASSROOM DEMONSTRATIONS: MORE THAN JUST ENTERTAINMENT?

**Catherine H. Crouch**
**Harvard University**

Calvin College
27 September 2001

# *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: many students learn little 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*

- **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)

# *Background*

**Research shows value of engaging all students**

- **think**
- **explain ideas**
- **discover misunderstandings**
- **ask questions**

# *Can demonstrations be more educational?*

**Does demonstration pedagogy affect:**

- **memory of outcome?**

# *Can demonstrations be more educational?*

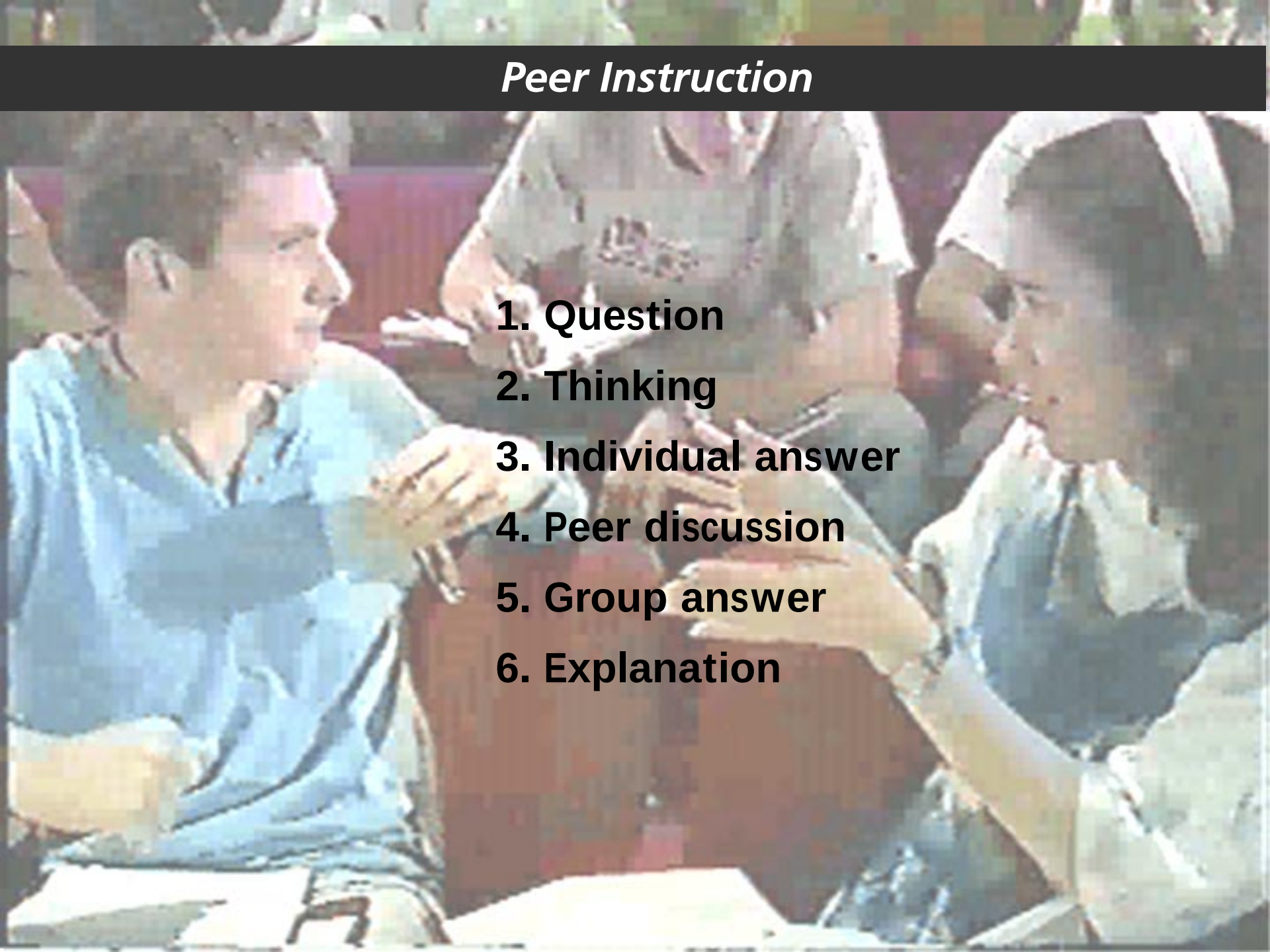
**Does demonstration pedagogy affect:**

- **memory of outcome?**
- **understanding of physics?**

# *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:**

# *Can demonstrations be more educational?*

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

# *Can demonstrations be more educational?*

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

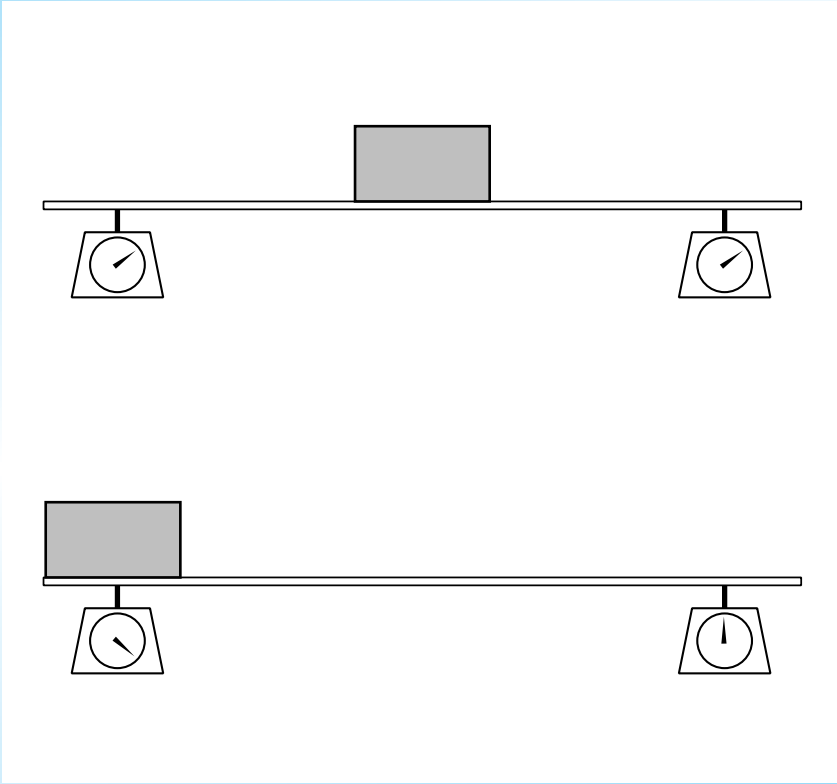
**7 demonstrations presented to 7 sections ($N \approx 15$) of introductory physics class in one of 4 ‘modes’:**

# *Research strategy*

**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 record prediction 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

# 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 $x$. The metal block is now placed over the right-hand scale.

---

**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).

# 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 $x$. The metal block is now placed over the right-hand scale.

---

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

## PREDICTION

---

**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).

# 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 $x$. The metal block is now placed over the right-hand scale.

---

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

## PREDICTION

---

**2**. Record your observation of the demonstration.

## OBSERVATION

---

**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).

# 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 $x$. The metal block is now placed over the right-hand scale.

---

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

## PREDICTION

---

**2**. Record your observation of the demonstration.

## OBSERVATION

---

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

__ Completely __ Mostly __ Somewhat __ Not at all

## 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).

# *Testing*

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

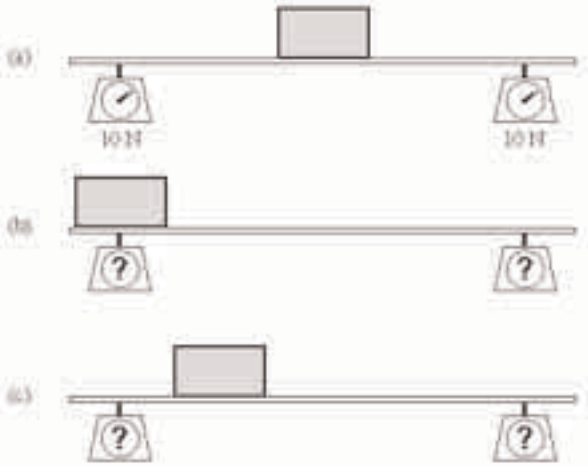
# *Testing*

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

# Testing

Physics 1 Third Computer Test

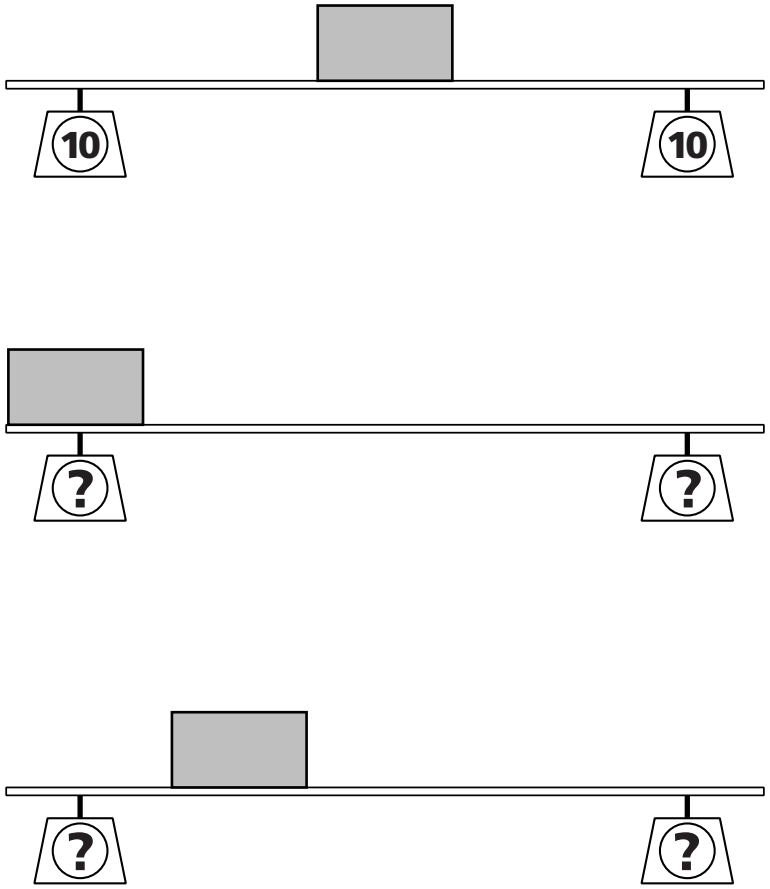
1 A plank of negligible mass is supported at its two ends by platform scales. When a block of metal is located at the center of the plank, halfway between the scales, the scales have the same reading of 10 N as shown in (a)




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.

# Testing



# *Results: Outcome of demonstrations*

| | correct outcome |
|---|---|
| no demo | |
| show | |
| predict | |
| reinforce | |

# *Results: Outcome of demonstrations*

| | correct outcome |
|---|---|
| no demo | 49% |
| show | |
| predict | |
| reinforce | |

# *Results: Outcome of demonstrations*

| | correct outcome |
|---|---|
| no demo | 49% |
| show | 54% |
| predict | |
| reinforce | |

# *Results: Outcome of demonstrations*

| | correct outcome | *P*-value |
|---|---|---|
| no demo | 49% | – |
| show | 54% | 0.86 |
| predict | | |
| reinforce | | |

# *Results: Outcome of demonstrations*

| | correct outcome | *P*-value |
|---|---|---|
| no demo | 49% | – |
| show | 54% | 0.86 |
| predict | 69% | 1.00 |
| reinforce | | |

# *Results: Outcome of demonstrations*

| | correct outcome | *P*-value |
|---|---|---|
| no demo | 49% | – |
| show | 54% | 0.86 |
| predict | 69% | 1.00 |
| reinforce | 69% | 1.00 |

# *Results: Outcome of demonstrations*

| | correct outcome | *P*-value | *P*-value |
|---|---|---|---|
| no demo | 49% | – | 0.86 |
| show | 54% | 0.86 | – |
| predict | 69% | 1.00 | 0.999 |
| reinforce | 69% | 1.00 | 0.999 |

# *'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."**

# *Results: Understanding*

| | fully correct | P-value | P-value |
|---|---|---|---|
| no demo | 22% | – | 0.68 |
| show | 24% | 0.68 | – |
| predict | 30% | 0.98 | 0.93 |
| reinforce | 32% | 0.99 | 0.97 |

# *Results: Understanding*

| | fully correct | P-value | P-value |
|---|---|---|---|
| no demo | 22% | – | 0.68 |
| show | 24% | 0.68 | – |
| predict | 30% | 0.98 | 0.93 |
| reinforce | 32% | 0.99 | 0.97 |

# *Results: Understanding*

| | fully correct | P-value | P-value |
|---|---|---|---|
| no demo | 22% | – | 0.68 |
| show | 24% | 0.68 | – |
| predict | 30% | 0.98 | 0.93 |
| reinforce | 32% | 0.99 | 0.97 |

# *Results: Understanding*

| | concepts correct | P-value | P-value |
|---|---|---|---|
| no demo | 24% | – | 0.74 |
| show | 26% | 0.74 | – |
| predict | 31% | 0.96 | 0.86 |
| reinforce | 34% | 0.99 | 0.93 |

# *Results: Cost vs. benefit*

| | time (min) | outcome gain | fully correct gain |
|---|---|---|---|
| show | 11 | 5% | 2% |
| predict | 13 | 20% | 8% |
| reinforce | 21 | 20% | 10% |

# *Results: Cost vs. benefit*

| | time (min) | outcome gain | fully correct gain |
|---|---|---|---|
| show | 11 | 5% | 2% |
| predict | 13 | 20% | 8% |
| reinforce | 21 | 20% | 10% |

# *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

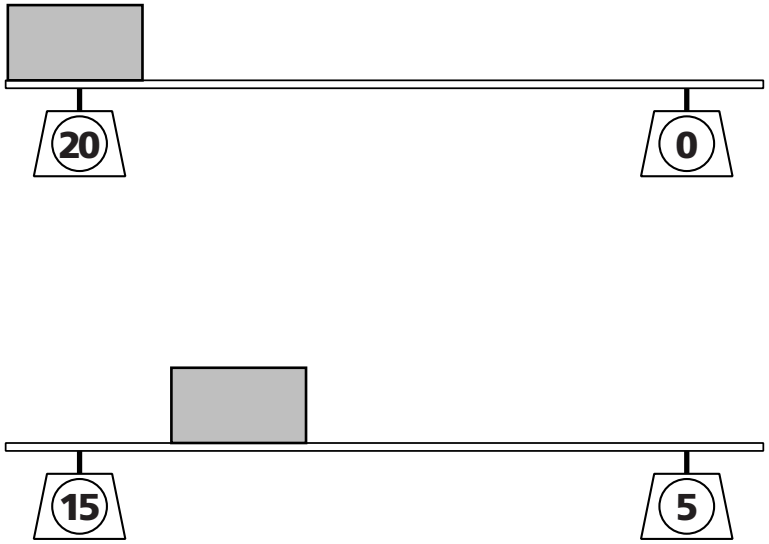
Research: Students and staff of Physics 1
Demonstrations: Wolfgang Rueckner, Nils Sorensen
Discussion: Gay Stewart

For a copy of this talk and
additional information:

**http://mazur-www.harvard.edu**

# Answers

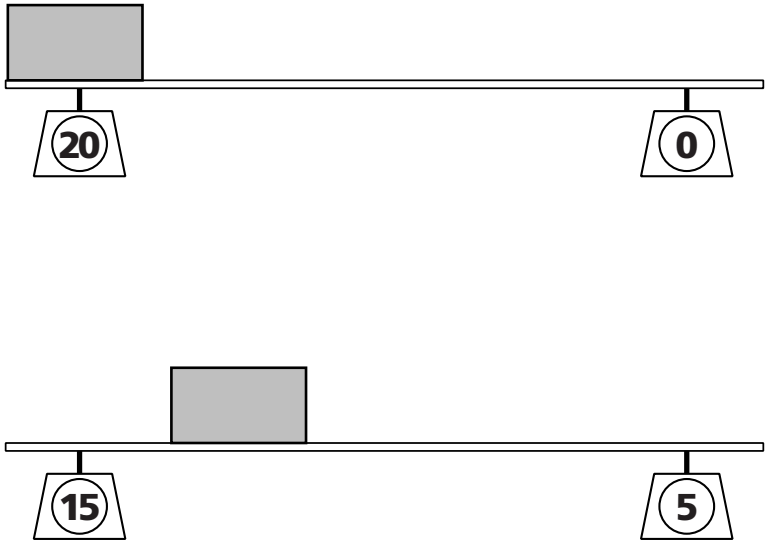
24% of students




correct (mentions torque)

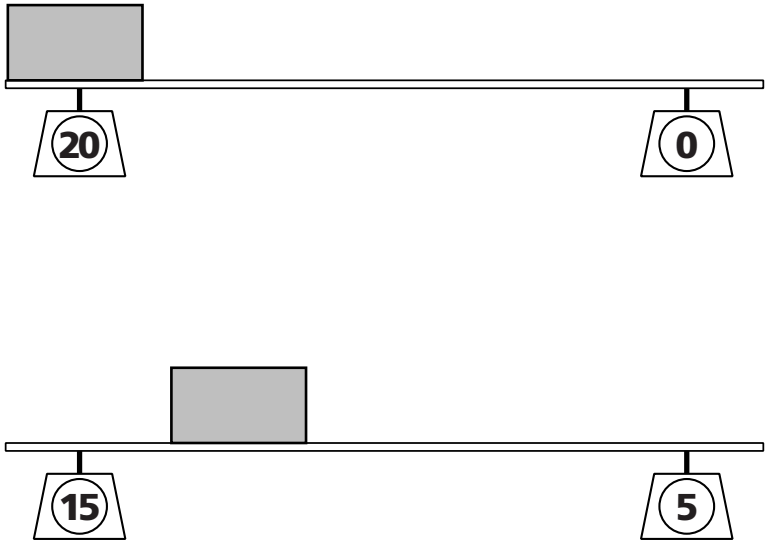
# Answers

24% of students




correct (mentions torque)

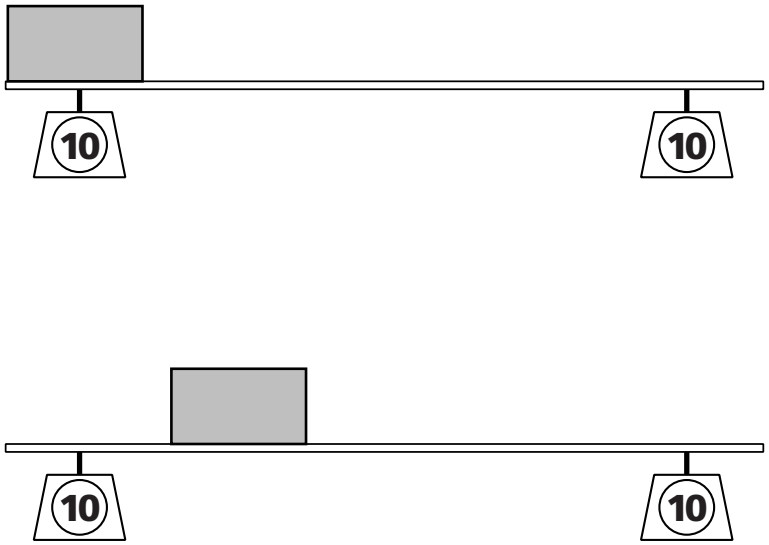
38% of students




proportional reasoning

# Answers

20% of students

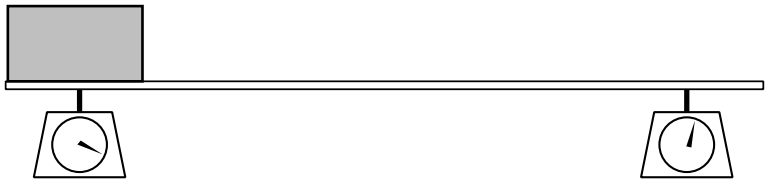


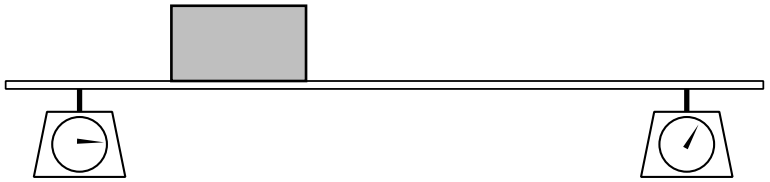




independent of position

10% of students





qualitative reasoning

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