CLASSROOM DEMONSTRATIONS: 
MORE THAN JUST ENTERTAINMENT?

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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
Psychology research: people remember what they expect to see

Education research: many students learn little from demonstrations
Research on learning from demonstrations:

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

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)
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
Peer Instruction: increase engagement by interspersing lectures with questions

Demonstrated improvement in student understanding of lecture material

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
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
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
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).
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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).
Web-based test

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

• questions identical to worksheets

• graded solely on effort

Analyze responses for \(N = 122, 7 \) questions:

• demonstration outcome

• physical understanding
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.
Results: Outcome of demonstrations

correct outcome

no demo

show

predict

reinforce
**Results: Outcome of demonstrations**

<table>
<thead>
<tr>
<th>correct outcome</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>no demo</td>
<td>49%</td>
</tr>
<tr>
<td>show</td>
<td></td>
</tr>
<tr>
<td>predict</td>
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<td>no demo</td>
<td>49%</td>
<td>–</td>
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<tr>
<td>show</td>
<td>54%</td>
<td>0.86</td>
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“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

<table>
<thead>
<tr>
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<th>P-value</th>
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<tr>
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<td>–</td>
<td>0.68</td>
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<tr>
<td>show</td>
<td>24%</td>
<td>0.68</td>
<td>–</td>
</tr>
<tr>
<td>predict</td>
<td>30%</td>
<td>0.98</td>
<td>0.93</td>
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<tr>
<td>reinforce</td>
<td>32%</td>
<td>0.99</td>
<td>0.97</td>
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## Results: Understanding

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<th>Method</th>
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<tbody>
<tr>
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<td>0.74</td>
</tr>
<tr>
<td>show</td>
<td>26%</td>
<td>0.74</td>
<td></td>
</tr>
<tr>
<td>predict</td>
<td>31%</td>
<td>0.96</td>
<td>0.86</td>
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<tr>
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### Results: Cost vs. benefit

<table>
<thead>
<tr>
<th>Action</th>
<th>time (min)</th>
<th>outcome gain</th>
<th>fully correct gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>show</td>
<td>11</td>
<td>5%</td>
<td>2%</td>
</tr>
<tr>
<td>predict</td>
<td>13</td>
<td>20%</td>
<td>8%</td>
</tr>
<tr>
<td>reinforce</td>
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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

20 0 20 0

15 5 15 5

correct (mentions torque)

38% of students

20 0

15 5

proportional reasoning
20% of students

10% of students

Independent of position

Qualitative reasoning

6% do not balance forces

2% give other incorrect answers