Research on Peer Instruction

Singapore Polytechnic
Singapore, 17 March 2015
Education
Education

not transfer but assimilation of information is key
Education

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Education

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let’s not abandon the scientific method when teaching
let’s not abandon the scientific method when teaching

The plural of anecdote is not data

Lee Shulman
Outline

• Gender issues
• Lecture demonstrations
• Confusion
Gender issues

Force Concept Inventory postest scores

![Bar chart showing average scores for men and women](chart.png)
Gender issues

Force Concept Inventory postest scores

Gender gap

average score (%)

women

men
Gender issues

Force Concept Inventory postest scores

![Graph showing gender gap in Force Concept Inventory postest scores]

Gender gap (%)

UMN

Percentage average score (%) men women gender gap

0 10 20 30 40 50 60 70 80 90 100

women men gender gap

0 20 40 60 80 100
Gender issues

Force Concept Inventory posttest scores

![Bar chart showing gender gap in posttest scores between men and women across institutions.]

- **UMN**: Gender gap (%): 20
- **Harvard**: Gender gap (%): 15
- **WPI**: Gender gap (%): 10
Gender issues

what causes this gap?
Gender issues

is it cultural?

![Gender Gap Chart](image)
Gender issues

![Bar chart showing gender gap (%)](chart)

- **Gender Gap (%)**: The chart illustrates the gender gap in FCI posttest scores between the US and Belgium.
- **FCI posttest**: The chart compares the gender gap in posttest scores, with Belgium showing a significantly higher gender gap compared to the US.
Gender issues

strong dependence on culture!

![Bar chart showing gender gap in FCI posttest across US, Belgium, and Taiwan.](chart.png)
Gender issues

effect of precollege education

![Graph showing average scores for women and FCI pretest. The x-axis represents levels of education: none, HS, and AP. The y-axis represents the average score in percentage. The graph indicates that the highest average score is for those with AP education, followed by HS, and the lowest is for those with no education.]
Gender issues

everyone gains...

![Graph showing average scores for FCI pretest and men with different levels (none, HS, AP).]
Gender issues

...but gap persists...

![Bar graph showing average score (%) for different levels of education: none, HS, and AP.](image-url)
Gender issues

...and women underrepresented
Gender issues

what can we do?
Gender issues

increase collaboration and interactivity
Gender issues

Compare three pedagogies:

T: traditional lectures

I: interactive lectures

I*: interactive assignments, lectures, and tutorials
Gender issues

does pedagogy help?

![Bar chart: average score (%) vs. treatment groups]

- **women**
- **FCI pretest**

Comparison of average scores across different treatments:

- **T**
- **IE**
- **IE+**
Gender issues

does pedagogy help?

![Bar chart showing average scores for women and men across different categories (T, IE, IE+).]
Gender issues

Does pedagogy help?

![Graph showing FCI posttest average scores for T, IE, and IE+](image-url)
Gender issues

yes, pedagogy can eliminate gap!

Gender issues

who are the low-gain students?

![Graph showing gain vs pretest score with a point indicating 20% gain at a pretest score of approximately 80%. Pretest: 70%, Posttest: 90%.]
Gender issues

traditional class

![Graph showing pretest score (%) vs. gain (%) for women in a traditional class. The graph indicates a negative correlation, with data points scattered below the line, suggesting that higher pretest scores correlate with lower gains.](image)
Gender issues

traditional class

[Graph showing the relationship between pretest score (%) and gain (%). The graph has two data sets: purple circles for women and red triangles for men. The trend line indicates a negative correlation.]
Gender issues

traditional class: gender imbalance

![Graph showing pretest score (%) vs. gain (%)]
Gender issues

interactive class

![Graph showing gain (%) against pretest score (%) for men and women. The graph indicates a trend where higher pretest scores correlate with lower gains.](image-url)
Gender issues

interactive class: gender balance

![Graph showing the relationship between pretest score and gain for men and women. The graph includes data points for both genders, with a trend line indicating a negative correlation between pretest score and gain.]
Gender issues

Points to keep in mind:

• gap comes from culture and background

• interactivity makes a difference
Lecture demonstrations

how effective are lecture demonstrations?
Lecture demonstrations

Carry out seven demonstrations in four “modes”:

- no demo (control)
- observe
- predict
- discuss
Lecture demonstrations

Carry out seven demonstrations in four “modes”:

- no demo (control)
- observe
- predict (+2 mins.)
- discuss (+8 mins.)
Lecture demonstrations

Follow up:

- free-response test (online)
- exam questions
Lecture demonstrations

loaded beam demo
Lecture demonstrations

online test question
Lecture demonstrations

20 0
15 5

24% of students

correct (mentions torque)
Lecture demonstrations

answers given

24% of students

20
0

correct (mentions torque)

38% of students

20
0

proportional reasoning
Lecture demonstrations

Answers given

20% of students

10% of students

Independent of position

Qualitative reasoning
Lecture demonstrations

answers given

20% of students

10% of students

independent of position

qualitative reasoning

6%: forces not balanced; 2%: other incorrect
# Lecture demonstrations

<table>
<thead>
<tr>
<th>mode</th>
<th>correct</th>
<th>incorrect</th>
</tr>
</thead>
<tbody>
<tr>
<td>no demo</td>
<td>30%</td>
<td>70%</td>
</tr>
<tr>
<td>observe</td>
<td>18%</td>
<td>82%</td>
</tr>
<tr>
<td>predict</td>
<td>29%</td>
<td>71%</td>
</tr>
<tr>
<td>discuss</td>
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</tr>
<tr>
<td>discuss</td>
<td>30%</td>
<td>70%</td>
</tr>
</tbody>
</table>

just presenting harmful?
A uniform plank is supported by two ropes at points $P$ and $Q$. The tension in the rope at $P$ is 150 N.
A uniform plank is supported by two ropes at points $P$ and $Q$. The tension in the rope at $P$ is 150 N. The point at which the other rope is attached to the plank is now moved to point $R$ halfway between $Q$ and the center of the plank. What are the tensions in the two ropes?
Lecture demonstrations

Correct answer

Considerable improvement from online test

36% of students
(30% w. corr. reasoning)
Lecture demonstrations

incorrect answers

13% of students

12% of students
Lecture demonstrations

incorrect answers

13% of students

lever arm reduced by factor 2

12% of students

lever arms 1:3
Lecture demonstrations
incorrect answers

\[
\left(\frac{3}{8}\right) 300 \text{ N} = 112.5 \text{ N} \quad \left(\frac{5}{8}\right) 300 \text{ N} = 187.5 \text{ N}
\]

112.5 N 112.5 N

8% of students 1% of students
Lecture demonstrations

incorrect answers

\[
\left( \frac{3}{8} \right) 300 \text{ N} = 112.5 \text{ N} \quad \left( \frac{5}{8} \right) 300 \text{ N} = 187.5 \text{ N}
\]

8% of students

\[
\begin{array}{ccc}
\text{P} & \text{R} & \text{Q} \\
3/8 \text{ plank} & 5/8 \text{ plank} & \\
\end{array}
\]

1% of students

\[
\begin{array}{ccc}
\text{P} & \text{R} & \text{Q} \\
112.5 \text{ N} & 112.5 \text{ N} & \\
\end{array}
\]

only 3/4 of plank supported

who would have thought??
<table>
<thead>
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<th>mode</th>
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<th>no clear reasoning</th>
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<td>42%</td>
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<td>55%</td>
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<tr>
<td>predict</td>
<td>41%</td>
<td>65%</td>
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<tr>
<td>discuss</td>
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### Lecture demonstrations

*aggregate results for seven demonstrations*

<table>
<thead>
<tr>
<th>mode</th>
<th>$N$</th>
<th>$R_{\text{outcome}}$</th>
<th>$R_{\text{explanation}}$</th>
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<td>61%</td>
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<td>24%</td>
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<tr>
<td>predict</td>
<td>179</td>
<td>77%</td>
<td>30%</td>
</tr>
<tr>
<td>discuss</td>
<td>158</td>
<td>82%</td>
<td>32%</td>
</tr>
</tbody>
</table>
Lecture demonstrations

improvement correlates with engagement

\[
\frac{R - R_{\text{no demo}}}{R_{\text{no demo}}}
\]

Lecture demonstrations

improvement correlates with engagement

\[
\frac{R - R_{\text{no demo}}}{R_{\text{no demo}}}
\]

Lecture demonstrations

Points to keep in mind:

• demonstrations without engagement not very helpful

• results can be improved by having students predict outcome
Confusion
Instructors are praised for ‘clear’ lectures.
confusion is discouraging, but...
confusion is discouraging, but…

“to wonder is to begin to understand”
Confusion

does confusion indicate lack of understanding?
Confusion

or, alternatively:

does lack of confusion indicate understanding?
Web-based free-response reading assignment:

- two questions on content (difficult!)
- one feedback question

Web-based free-response reading assignment:

- two questions on content (difficult!)
- one feedback question

analyze understanding and confusion

Novak et al., Just-in-Time Teaching: Blending active learning with web technology (Prentice Hall, 1999).
1. Consider the capillary rise of a liquid in a glass tube. How does the pressure at point $P$ at the surface of the liquid compare to the pressure at point $Q$ at equal height?
1. Consider the capillary rise of a liquid in a glass tube. How does the pressure at point $P$ at the surface of the liquid compare to the pressure at point $Q$ at equal height?

2. Two identical balloons are connected to a tube as shown below. Balloon $B$ is inflated more than balloon $A$. Which way does the air flow when valve $P$ is opened?
3. Please tell us briefly what points of the reading you found most difficult or confusing. If you did not find any part of it difficult or confusing, please tell us what parts you found most interesting.
1. Capillary action is due to the cohesion between water molecules, and the adhesion of water to the surface of the glass tube. Negative pressures can result from the cohesive forces of water. At the same height, the pressure inside the tube is much less due to negative pressures.

2. The air flows from high pressure to low pressure. The fully blown up balloon has higher pressure than the 1/2 blown up balloon. So the air flows from the fully blown balloon to the half filled balloon.

3. Nothing was difficult or confusing. The sections on the surfactant in the lungs and the heart as a pump were interesting because they relate physics to biology.
Confusion

sample answer

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3. Nothing was difficult or confusing. The sections on the surfactant in the lungs and the heart as a pump were interesting because they relate physics to biology.
1. The water rises because of an interaction between the water and the walls of the tube. This interaction creates an upward force which causes the water to rise. The force is due to surface tension between the water and the walls of the tube. The pressure at the point inside the tube must be the same as the pressure at the point of equal height outside the tube, because if there was a pressure difference, then there would be a net flow of water, into or out of the tube, until the pressure difference was equalized.

2. Laplace’s law tells us that it requires a greater pressure difference to maintain a small sphere than a larger one. So, the pressure in the small balloon must be greater, and the air will flow from the small balloon into the large one.

3. I found the explanation of Laplace’s law to be inadequate, and while I can understand the conclusion drawn, I don’t understand the reasoning which led to the conclusion.
Confusion

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Analysis

Coding of responses:

• Q1 and Q2: correct or incorrect
• Q3: confusion expressed on topic of Q1/Q2

Correlate confusion with correctness
Confusion

traditional textbook on Laplace’s law and capillarity

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<td>56%</td>
</tr>
<tr>
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<td>25%</td>
<td>75%</td>
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Confusion

traditional textbook on Laplace’s law and capillarity

<table>
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<td>51%</td>
</tr>
<tr>
<td>not confused</td>
<td>21%</td>
<td>79%</td>
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“Confused” students twice as likely correct!
Confusion
using research-based text

<table>
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<th>torque</th>
<th>correct</th>
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</tr>
</thead>
<tbody>
<tr>
<td>confused</td>
<td>45%</td>
<td>55%</td>
</tr>
<tr>
<td>not confused</td>
<td>43%</td>
<td>57%</td>
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</table>
Confusion using research-based text

text compels students to think while reading

<table>
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<tr>
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<th>correct</th>
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</thead>
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<td>55%</td>
</tr>
<tr>
<td>not confused</td>
<td>43%</td>
<td>57%</td>
</tr>
</tbody>
</table>
More confusion among students who understand! (especially when students are not pushed to think)
Confusion

Confusion...

• doesn’t correlate with understanding
• is not (necessarily) the result of poor teaching
• is part of the learning process
classroom data vital to improving education!
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