Gender, interactive teaching, and barriers to change

Women in Science and Engineering Workshop
Thomas Jefferson National Accelerator Facility
Newport News, VA, 16 November 2009
Education
lectures focus on delivery of information
not transfer but assimilation of information is key
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 gap
• Interactive teaching
• Confusion
Gender issues

Force Concept Inventory posttest scores

average score (%)

0 20 40 60 80 100

women men
Gender issues

Force Concept Inventory posttest scores

average score (%)

gender gap

women
men
Gender issues

Force Concept Inventory postest scores

Gender gap (%)

UMN

Average score (%)

Men
Women
Gender gap
Gender issues

Force Concept Inventory posttest scores

<table>
<thead>
<tr>
<th>Gender Gap (%)</th>
<th>UMN</th>
<th>Harvard</th>
<th>WPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender Gap (%)</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The chart shows the gender gap in Force Concept Inventory posttest scores at UMN, Harvard, and WPI.
Gender issues

what causes this gap?
Gender issues

is it cultural?

![Gender Gap Chart](image)
Gender issues

![Gender gap chart](image)

The chart shows the gender gap in FCI posttest scores between the US and Belgium. The gender gap is significantly higher in Belgium compared to the US.
Gender issues

strong dependence on culture!

![Gender Gap Chart]

<table>
<thead>
<tr>
<th>Country</th>
<th>Gender Gap (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>10</td>
</tr>
<tr>
<td>Belgium</td>
<td>20</td>
</tr>
<tr>
<td>Taiwan</td>
<td>5</td>
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</table>

FCI posttest
Gender issues

effect of precollege education

![Bar chart showing the average score (%) for women and FCI pretest with three categories: none, HS, AP. The scores are 0 for none, 40 for HS, and 80 for AP.](chart.png)
Gender issues

everyone gains...

![Bar chart showing average scores for FCI pretest and men for different levels of education (none, HS, AP).]
Gender issues

…but gap persists…

![Bar chart showing average scores for different levels of education: none, HS, AP. The chart indicates that while there is a gap between male and female scores, it persists regardless of educational level.](chart.png)
Gender issues

...and women underrepresented
Gender issues

what can we do?
Gender issues

increase collaboration and interactivity
Compare three pedagogies:

T: traditional lectures

I: interactive lectures

I+: interactive assignments, lectures, and tutorials
does pedagogy help?
Gender issues

does pedagogy help?

![Bar chart showing average scores for women and men across different conditions (T, IE, IE+) with purple and red bars.](chart.png)
Gender issues

does pedagogy help?

![Bar chart showing average score (%) for FCI posttest, with categories T, IE, and IE+.]
Gender issues

yes, pedagogy can eliminate gap!

![Bar chart showing FCI posttest results]

Gender issues

Points to keep in mind:

• gap comes from culture and background

• interactivity makes a difference
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

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?
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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.
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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.
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Confusion

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

<table>
<thead>
<tr>
<th>capillarity</th>
<th>correct</th>
<th>incorrect</th>
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<tbody>
<tr>
<td>confused</td>
<td>44%</td>
<td>56%</td>
</tr>
<tr>
<td>not confused</td>
<td>25%</td>
<td>75%</td>
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<table>
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<tr>
<th>Laplace</th>
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<tbody>
<tr>
<td>confused</td>
<td>49%</td>
<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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<tr>
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<th>incorrect</th>
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</thead>
<tbody>
<tr>
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<td>45%</td>
<td>55%</td>
</tr>
<tr>
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<td>57%</td>
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## Confusion

Using research-based text

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Text compels students to think while reading
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!
Acknowledgments:

Catherine Crouch
Mercedes Lorenzo
Paul Callan
Adam Fagen
Jessica Watkins
Emily Fair Oster

Pat and Ken Heller (UMN)
Laura McCullough (UMN)
Steve Pierson (WPI)
Tom Keil (WPI)
Funding:

National Science Foundation

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