UNDERSTANDING OR MEMORIZATION: ARE WE TEACHING THE RIGHT THING?

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Problem
Outline

- Problem
- Cause
Outline

- Problem
- Cause
- Remedy
We have a problem

380,000 students take introductory physics each year...

We have a problem

about 1% of these get a bachelor’s degree in physics

We have a problem

Of the 4,300 students with a bachelor’s degree in physics...

We have a problem

about 35% go on to get a Ph.D. in physics...

We have a problem

That’s one out of every 260 students in our introductory courses!
We have a problem

What about the other 259...?
We have a problem

What do we know about these students?
We have a problem

Some disturbing symptoms:

- frustration
- lack of understanding
- lack of basic knowledge
We have a problem

They know the jargon:

- circular motion
- barometric pressure
- light radius
- something to the power times ten to the something
We have a problem

They are aware of their lack of knowledge

- I graduated from college but I didn’t study *astronomy*
- It’s been a while since I’ve had physics
We have a problem

They are aware of their lack of knowledge

- I graduated from college but I didn’t study astronomy
- It’s been a while since I’ve had physics

...and they don’t care!
We have a problem

Should we worry?
We have a problem

We’d better!
“I took four years of science and four years of math...

A waste of my time, a waste of the teacher’s time, and a waste of space...

You know, I took physics.

For what?”
Why do we have this problem?
Why do we have this problem?

Lectures focus on transfer of information...
Why do we have this problem?

... but physics is not just information!

Hestenes, et al., TPT 30, 141 (1992)
Why do we have this problem?

…but physics is not just information!

![Histogram showing score distribution](image-url)
Why do we have this problem?

... but physics is not just information!
Why do we have this problem?

[Graph showing change in score, $S_f - S_i$ (%) vs. initial score, $S_i$ (%)]
Why do we have this problem?

![Bar chart showing change in score, $S_f - S_i$, versus initial score, $S_i$, with an inset labeled 1990 combined.](chart.png)
Why do we have this problem?
Why do we have this problem?

![Graph showing the relationship between initial score, $S_i$, and change in score, $S_f - S_i$. The graph includes a perfect score line and scattered data points.]
Why do we have this problem?

\[ g = \frac{S_f - S_i}{1 - S_i} \]

change in score, \( S_f - S_i \) (

initial score, \( S_i \) (%)

1.00

0.23

perfect score
Why do we have this problem?

Conventional problems reinforce bad study habits
Why do we have this problem?

Conventional problems reinforce bad study habits
Why do we have this problem?

Conventional problems reinforce bad study habits

Calculate:

(a) the current in the $2\Omega$ resistor, and

(b) the potential difference between points $P$ and $Q$
Why do we have this problem?

Are basic principles understood?
Why do we have this problem?

Are basic principles understood?

When $S$ is closed, what happens to the:

(a) intensities of $A$ and $B$?
(b) intensity of $C$?
(c) current through battery?
(d) voltage drop across $A$, $B$, and $C$?
(e) total power dissipated?
Why do we have this problem?

conventional

conceptual
Why do we have this problem?

![Bar graphs comparing conventional and conceptual approaches.](image)

- **Conventional**
  - Average: 6.9
  - Score distribution:
    - Score 0-2: Low count
    - Score 4: Moderate count
    - Score 6-8: High count
    - Score 10: Low count

- **Conceptual**
  - Average: 4.9
  - Score distribution:
    - Score 0-2: Low count
    - Score 4: Moderate count
    - Score 6: Moderate count
    - Score 8: Moderate count
    - Score 10: Low count
Why do we have this problem?
Why do we have this problem?
So what should we do?
Help students take more responsibility for learning!
Peer Instruction

Main features:

» Pre-class reading
» In class: depth, not coverage
» ConcepTests
1. Question
2. Thinking
3. Individual answer
4. Peer discussion
5. Group answer
6. Explanation
Is it any good?
Results
Is it any good?

- Results
- Student Reactions
Results

1991 FCI pretest

Count

Score

0 5 10 15 20 25
Results

1991 FCI posttest

count

score

0 5 10 15 20 25

0 5 10 15 20 25
Results

![Bar chart showing scores and counts for 1991 combined]
Results

\[ g = \frac{S_f - S_i}{1 - S_i} \]

change in score, \( S_f - S_i \) (%)

initial score, \( S_i \) (%)
Results

change in score, $S_f - S_i$ (%)

initial score, $S_i$ (%)
Results

The graph shows the relationship between the initial score, $S_i$ (percentage), and the change in score, $S_f - S_i$ (percentage). The equation for the line of best fit is given by $g = \frac{S_f - S_i}{1 - S_i}$.

The graph has a scale from 0 to 100 for both the initial score and the change in score. The line passes through the points (0, 1.00) and (100, 0.23), indicating the perfect score scenario.

The data points are scattered across the graph, with colors indicating different categories or groups.
Results

\[ g = \frac{S_f - S_i}{1 - S_i} \]

Initial score, \( S_i \) (%)

Change in score, \( S_f - S_i \) (%)

Perfect score

0.23
0.48
1.00
Results

What about problem solving…?
Results

1985 exam scores

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<th>count</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>5</td>
<td>10</td>
<td>15</td>
<td>20</td>
<td>25</td>
</tr>
</tbody>
</table>

exam score (%)
Results

1991 exam scores

exam score (%)

count

0 20 40 60 80 100

0 5 10 15 20 25
Results

1985/91
exam scores

Count

Exam score (%)

25
20
15
10
5
0

100
80
60
40
20
0
Results

So better understanding leads to better problem solving!
So better understanding leads to better problem solving!

(but “good” problem solving doesn’t always indicate understanding!)
Let’s not forget the base of the pyramid!
Let’s give them something of value!
Conclusion

Challenges:

- internal skepticism
- growing pains
- limited circle of influence
Conclusion

Rewards:

- engagement
- improved understanding
- class is fun!
Funding

National Science Foundation

For a copy of this talk and additional information:

http://mazur-www.harvard.edu