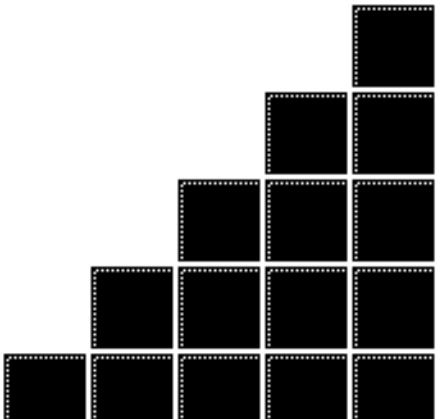

VE
RI
TAS

UNDERSTANDING OR MEMORIZATION: ARE WE TEACHING THE RIGHT THING?

Eric Mazur
Harvard University

193 rd AAS Meeting
Austin, TX
7 January 1999



❶ Problem

❷ Cause

❸ Remedy

PROBLEM? WHAT PROBLEM?

Traditional science education ineffective...

- lack of understanding
- frustration
- lack of basic knowledge

LACK OF UNDERSTANDING

LACK OF UNDERSTANDING

Well, "hot" is a relative term...

You see, given temperatures rise, regardless of mass.

Yeah, Galileo observed rising temperatures will decrease with the exposure of an endothermic source.

Endothermic?

True transparence will persist until this one irresistible calorie interacts, thus altering the system.

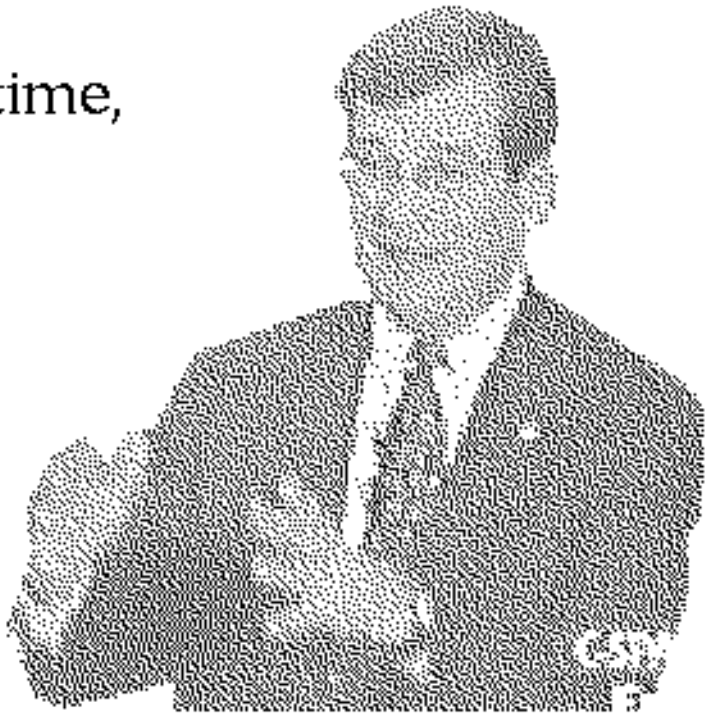
FRUSTRATION

FRUSTRATION

"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*?"

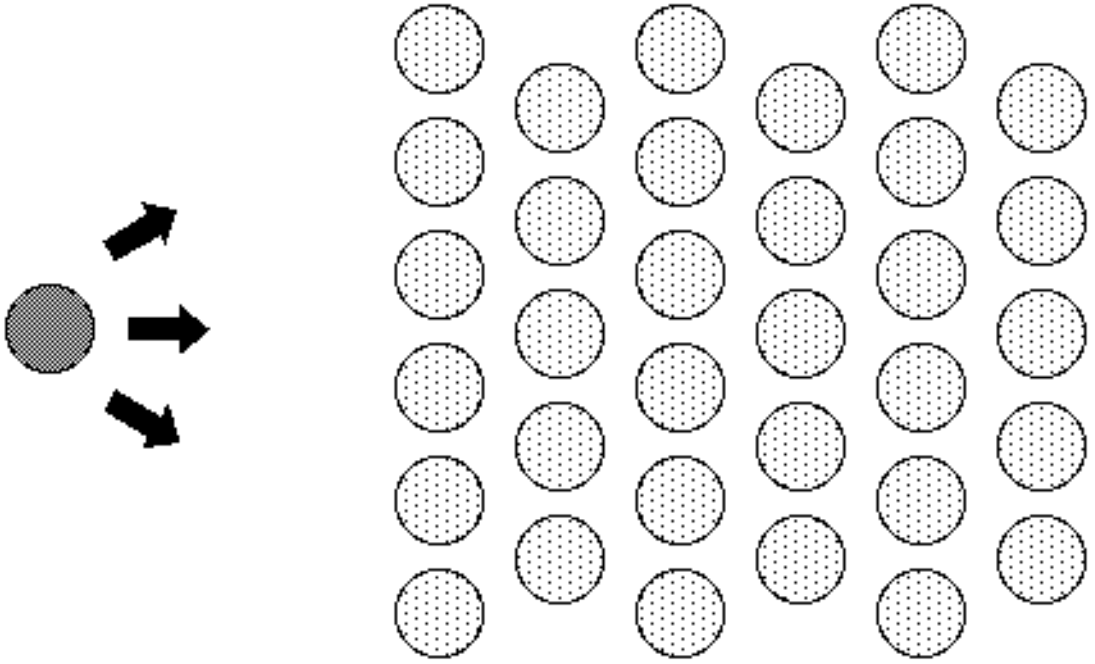


FRUSTRATION

LACK OF BASIC KNOWLEDGE

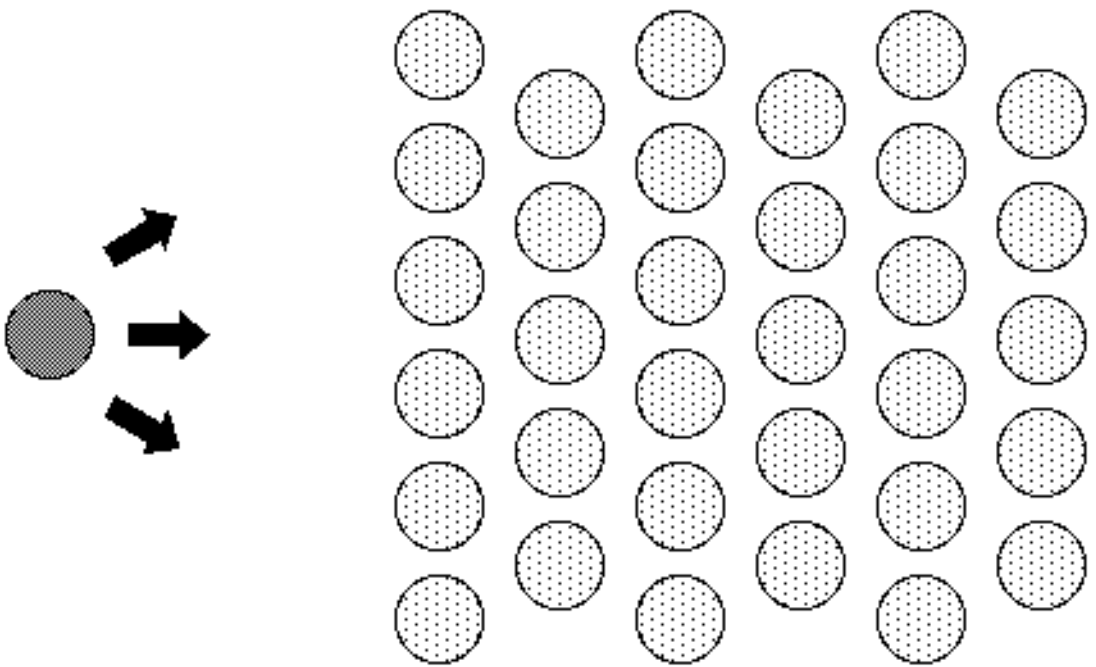
THE CAUSE

1. Lectures focus on transfer of information...

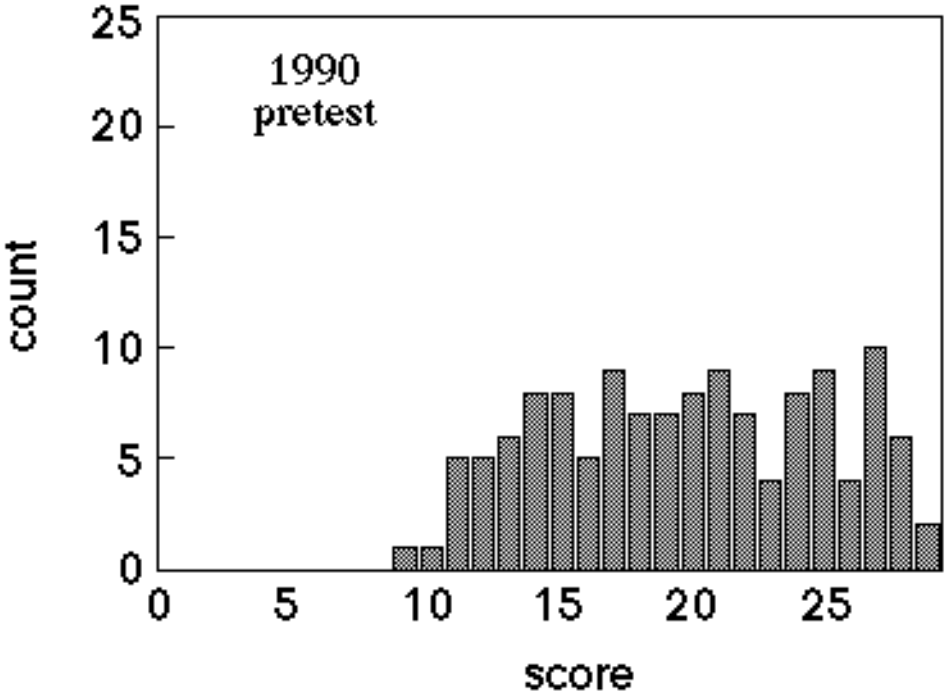


THE CAUSE

... but the information doesn't sink in!

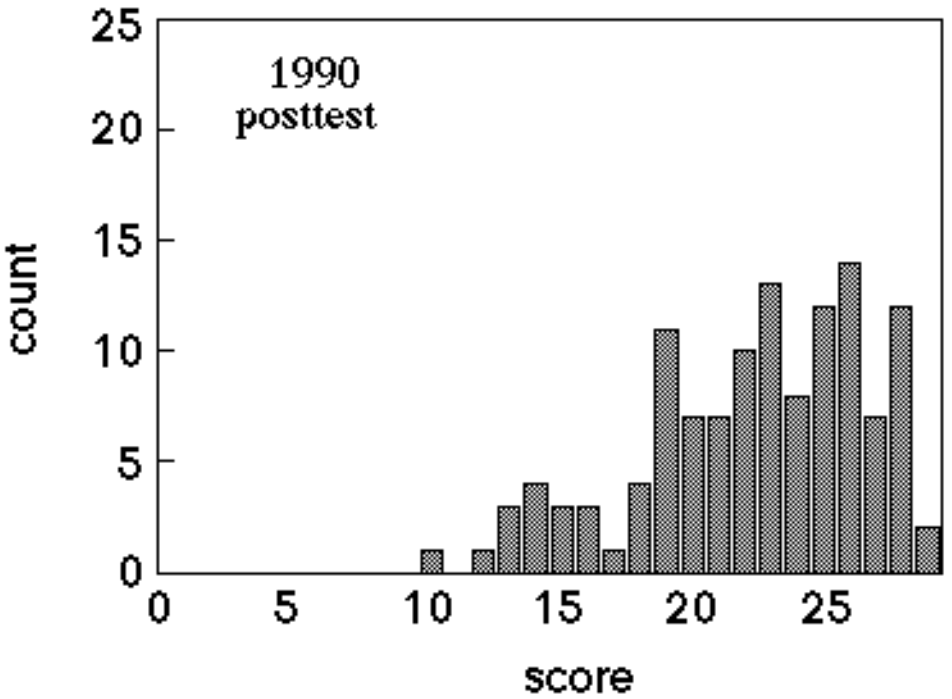


THE CAUSE

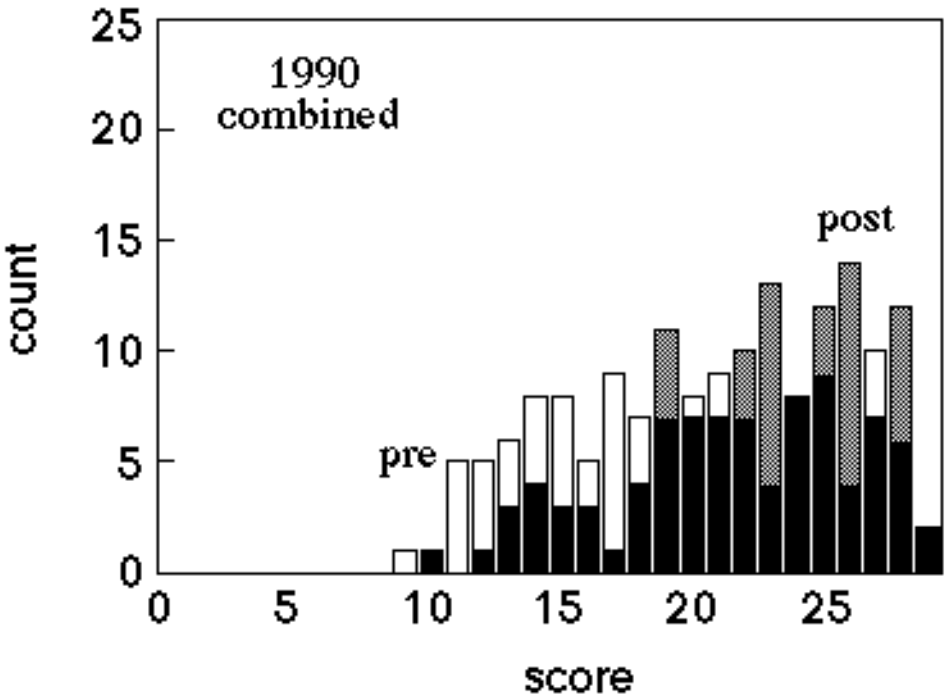


☞ Hestenes, *et al.*, TPT **30**, 141 (1992)

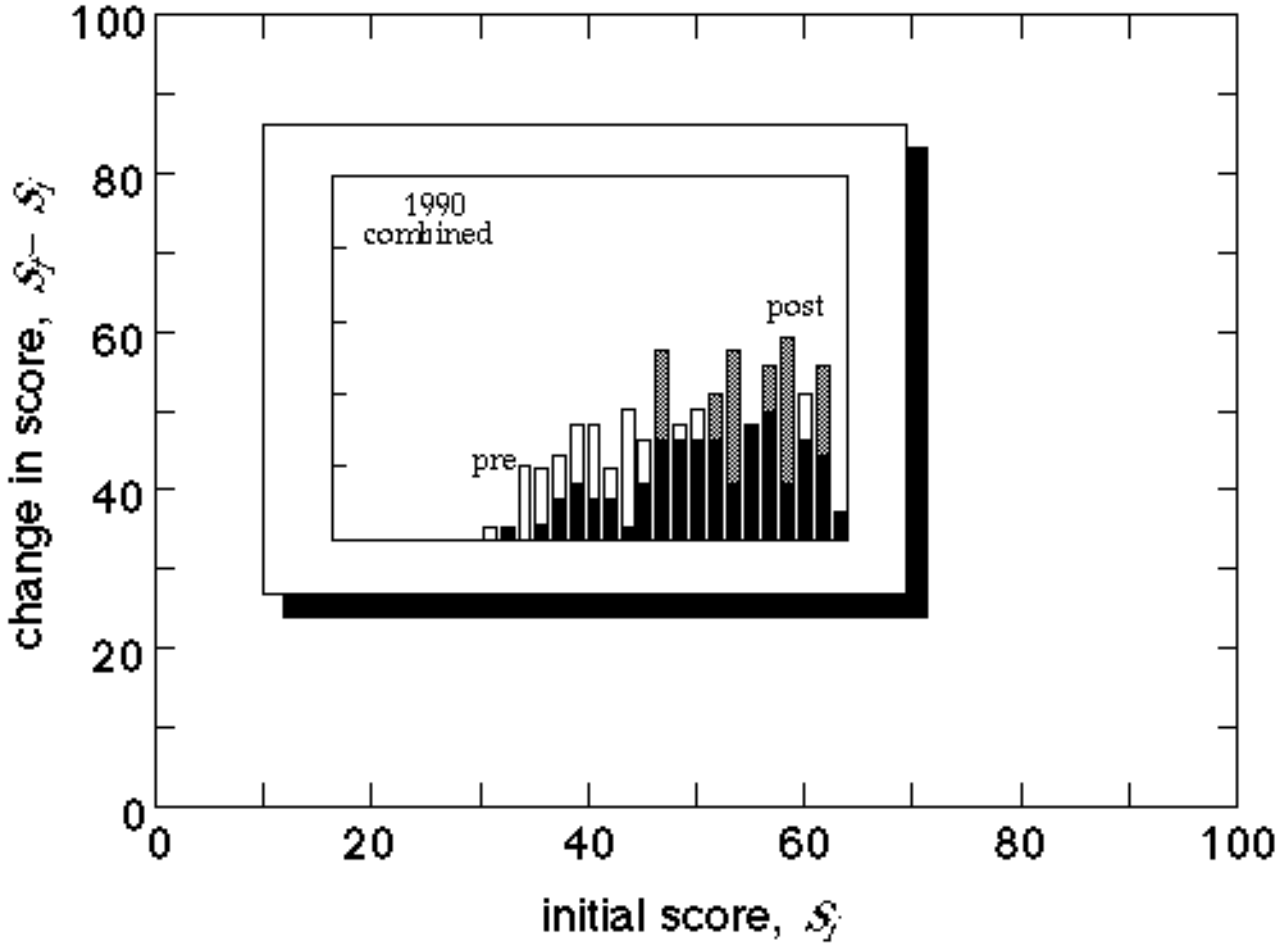
THE CAUSE



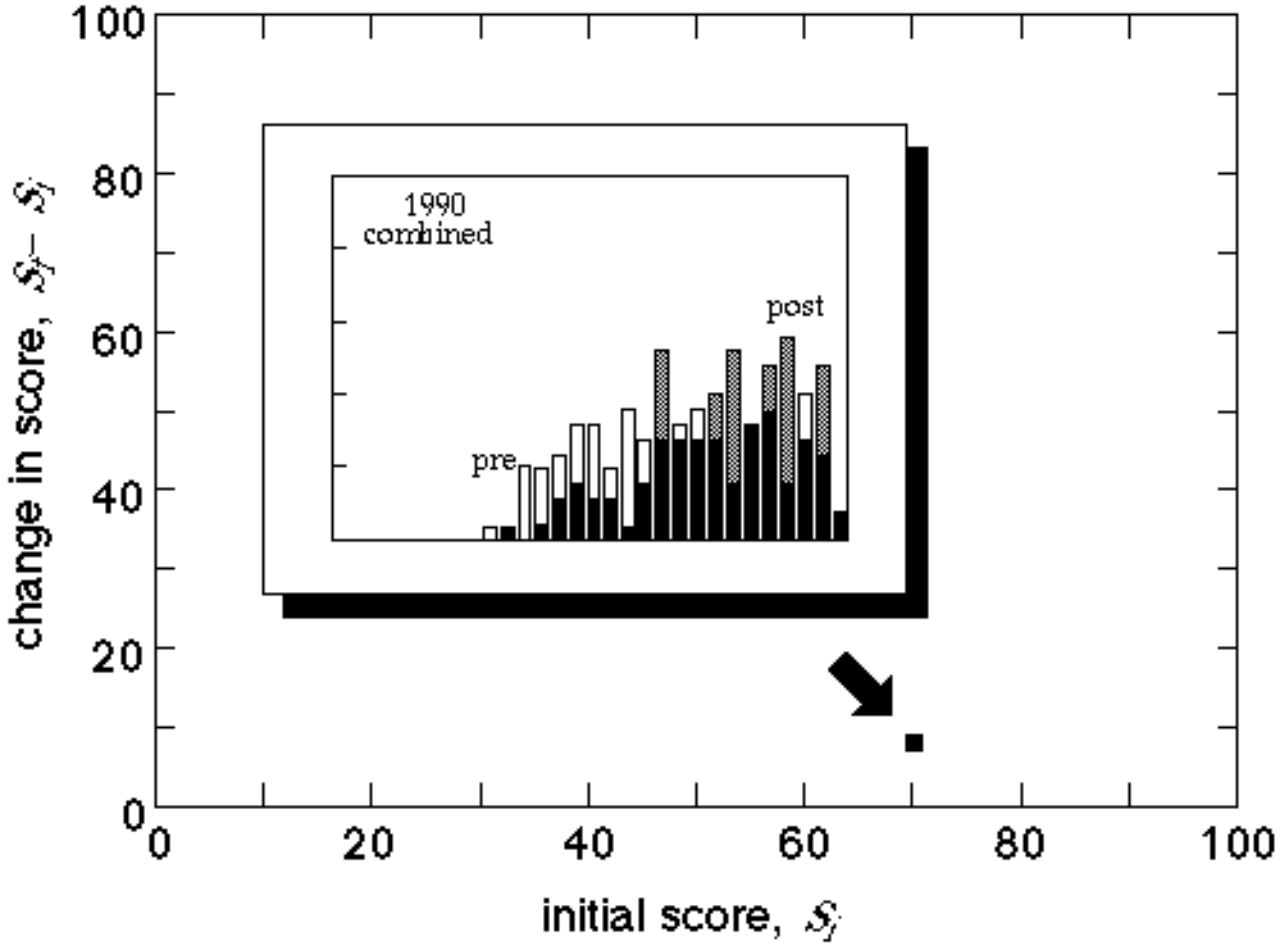
THE CAUSE



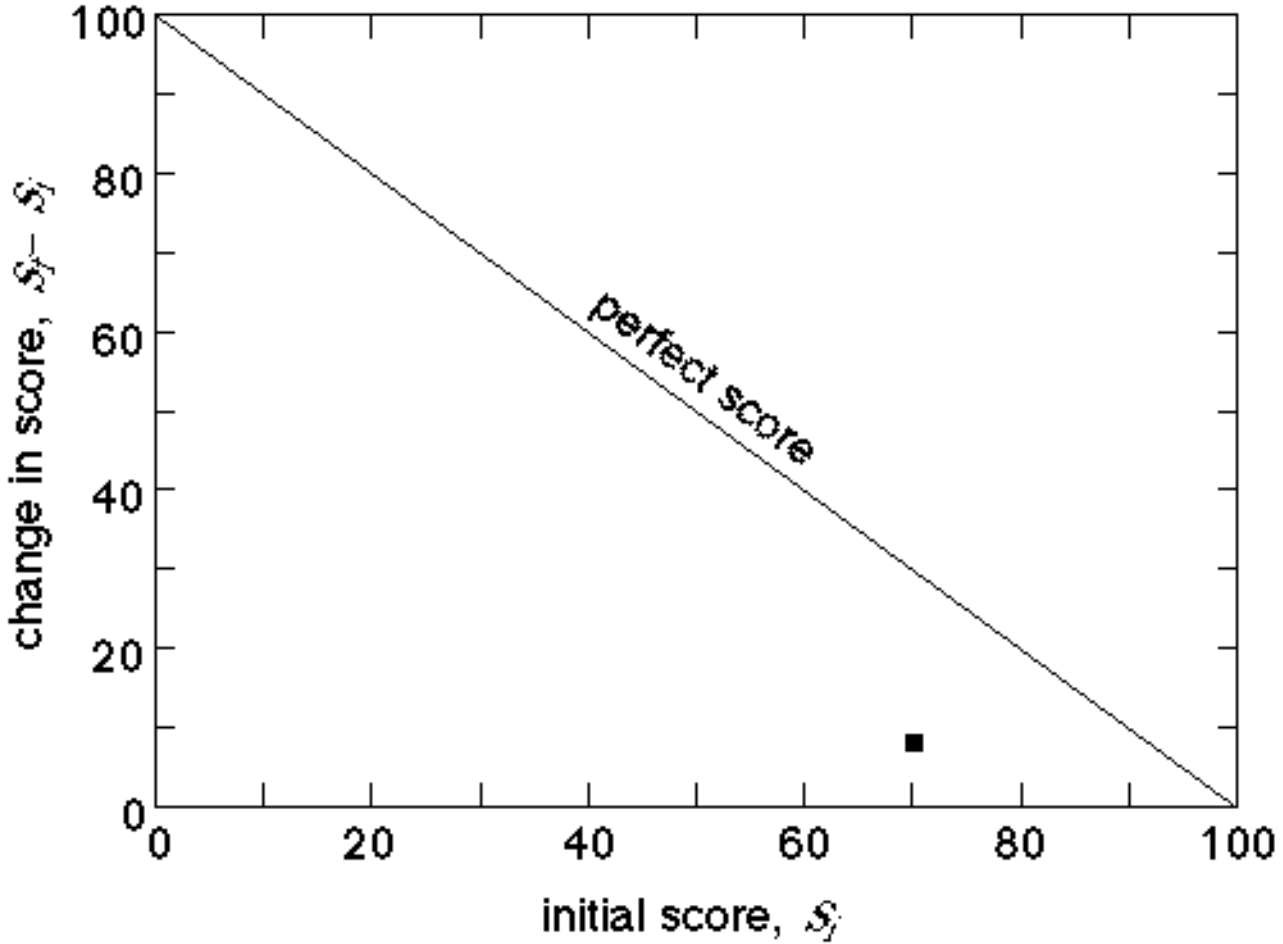
THE CAUSE


100
80
60
40
20
0
0
20
40
60
80
100
change in score, $S_f - S_i$
initial score, S_i
1990
combined
post
pre

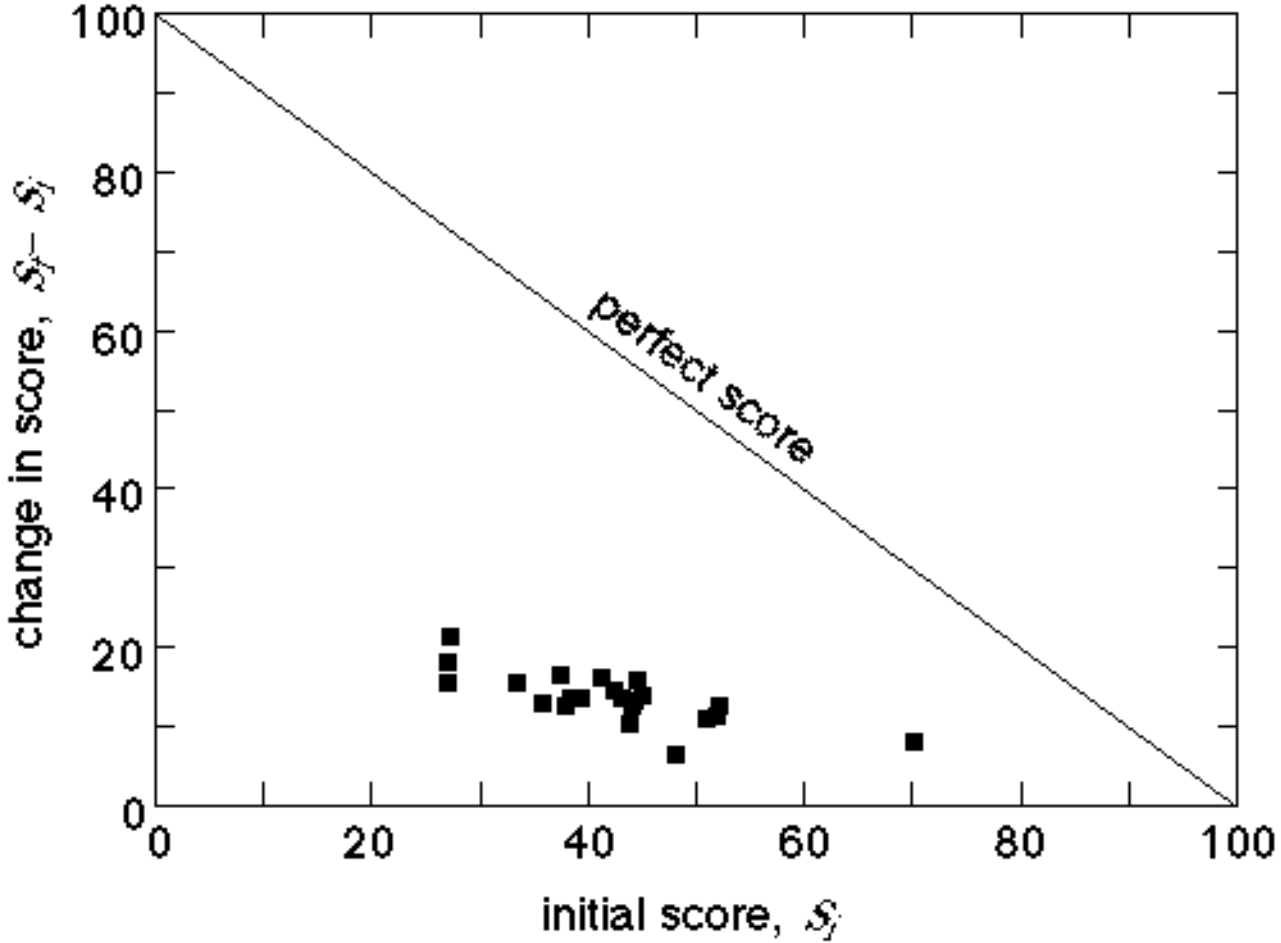
THE CAUSE


100
80
60
40
20
0
0
20
40
60
80
100
change in score, $S_f - S_i$
initial score, S_i
1990
combined
post
pre

THE CAUSE

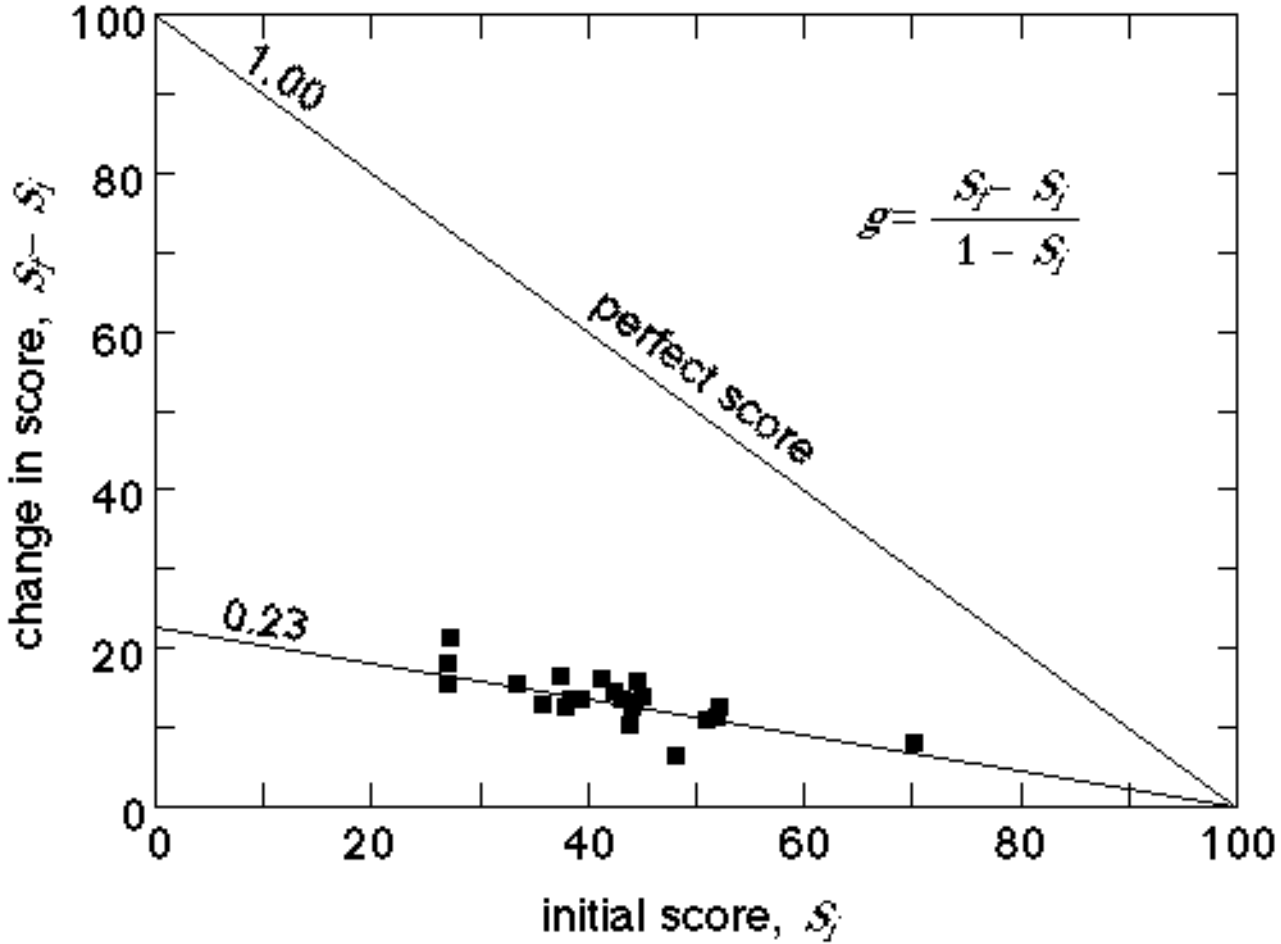

100
80
60
40
20
0
0
20
40
60
80
100
change in score, $S_f - S_i$
initial score, S_i
perfect score

THE CAUSE



☞ Hake, AJP **66**, 64 (1998)

THE CAUSE



☞ Hake, AJP **66**, 64 (1998)

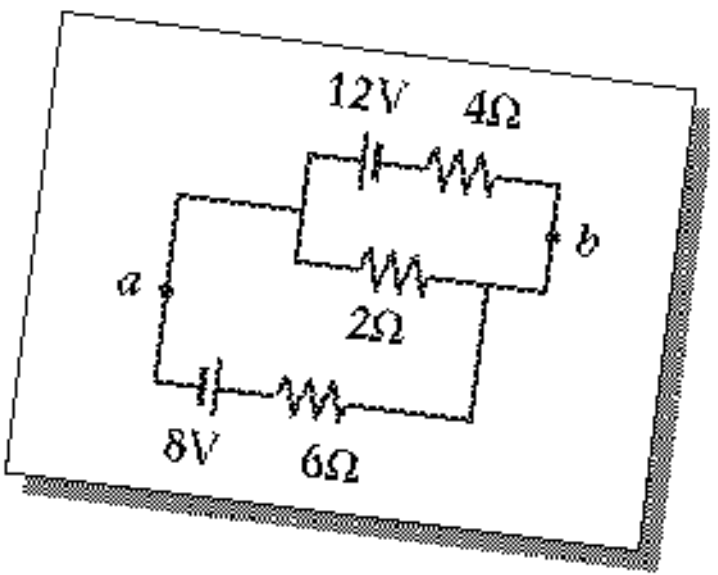
THE CAUSE

2. Conventional problems reinforce bad study habits

Calculate:

(*a*) the current in the 2-Ω resistor, and

(*b*) the potential difference between points *a* and *b*.

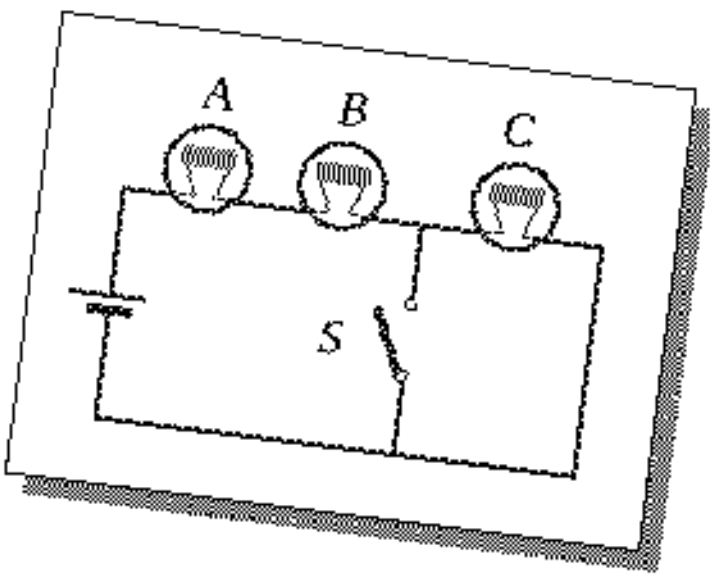


THE CAUSE

Are basic principles understood?

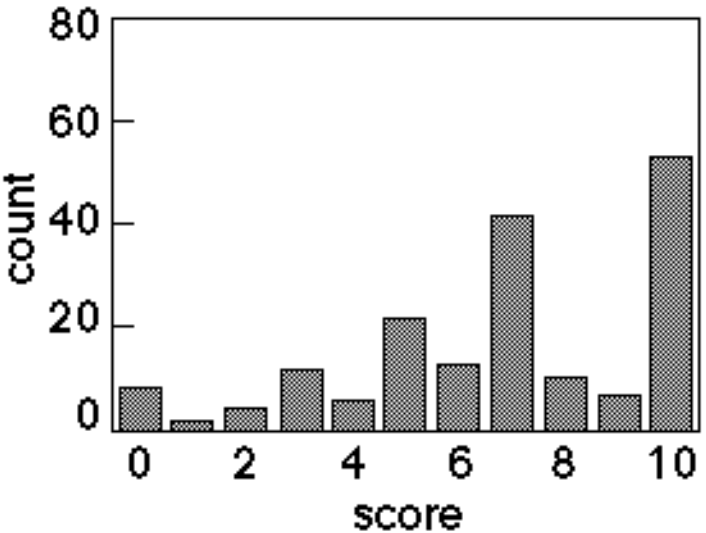
When *S* is closed, what happens to the:

(*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?

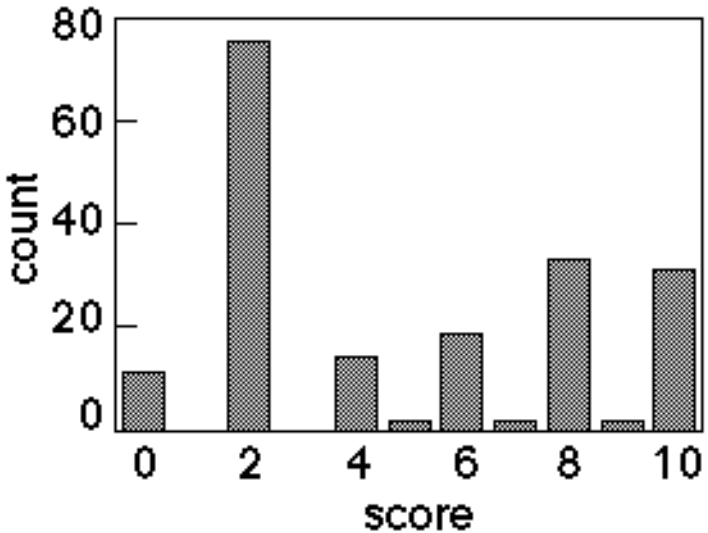


THE CAUSE

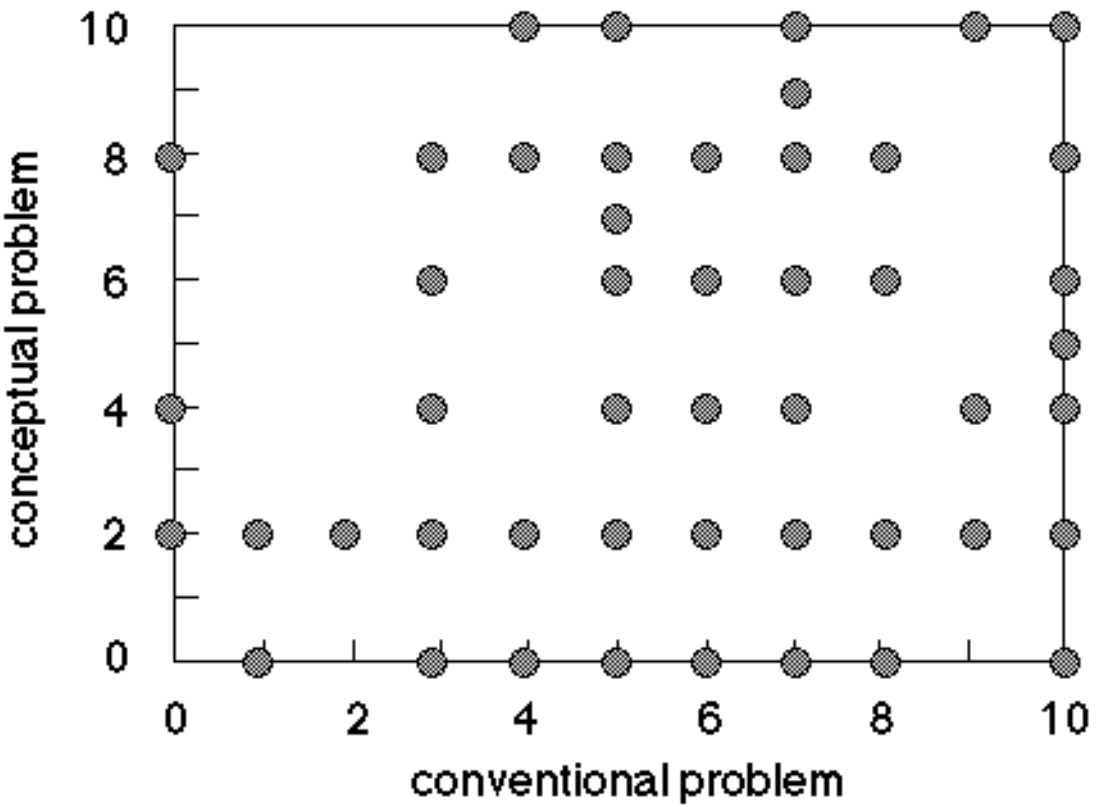
conventional



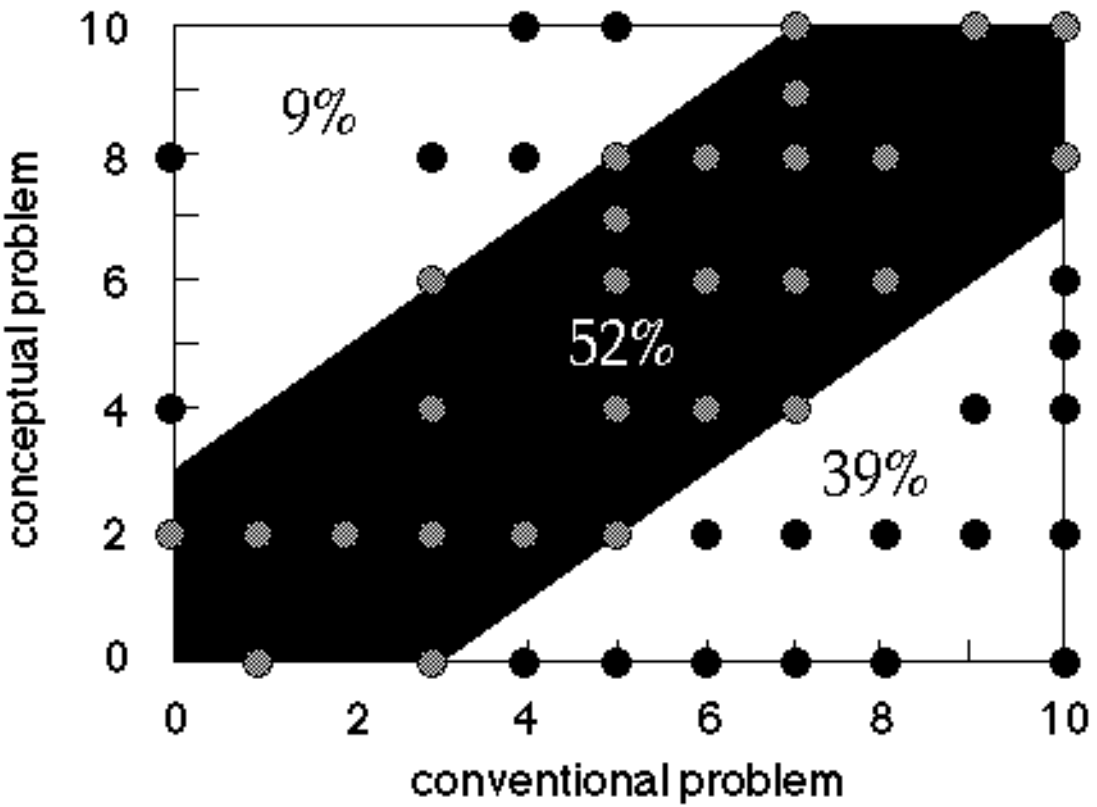
conceptual



THE CAUSE


10
8
6
4
2
0
conceptual problem
0
2
4
6
8
10
conventional problem

THE CAUSE


10
8
6
4
2
0
conceptual problem
9%
52%
39%
0
2
4
6
8
10
conventional problem

❶ Problem

❷ Cause

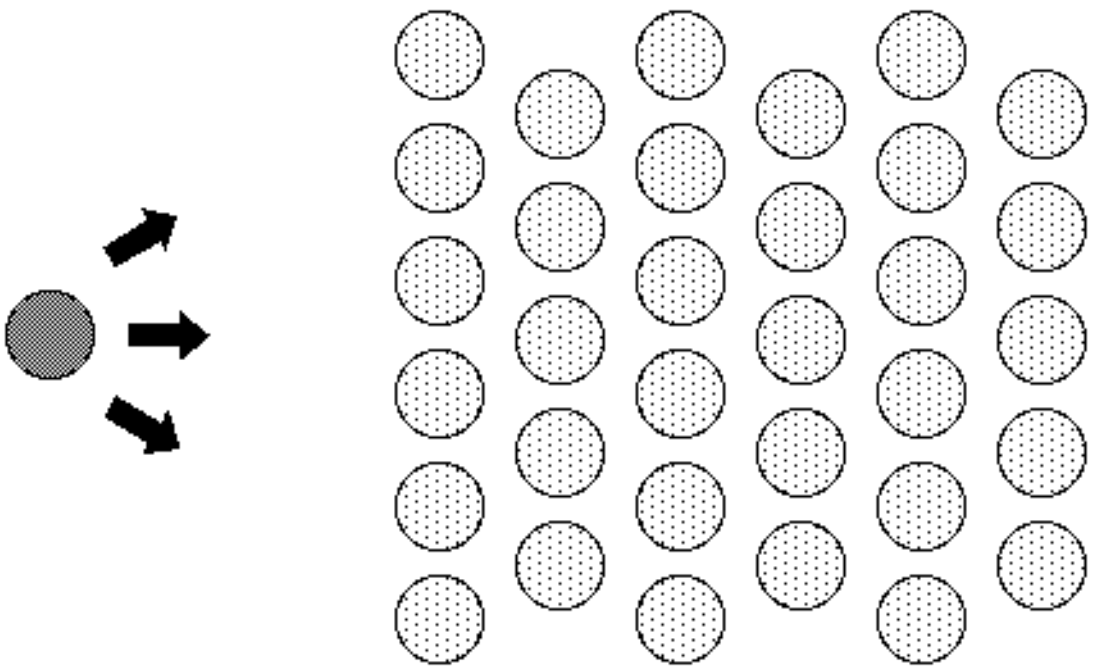
❸ Remedy

PEER INSTRUCTION

Give students more responsibility for learning!

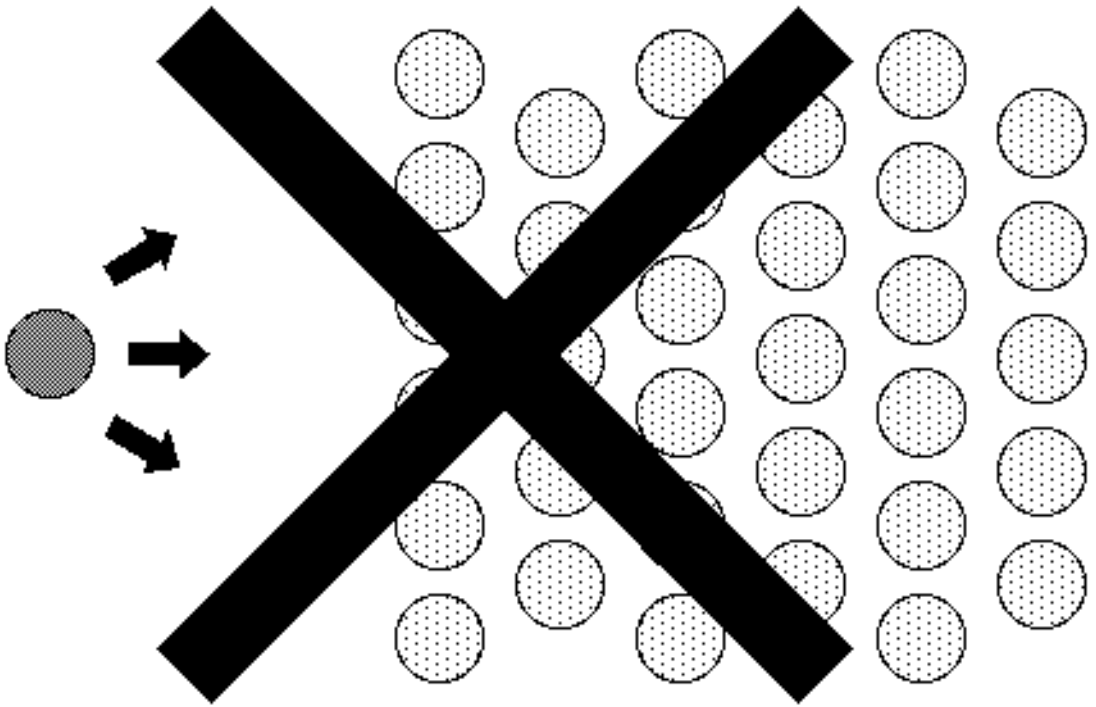
PEER INSTRUCTION

1. Recognize the inefficacy of the lecture method!

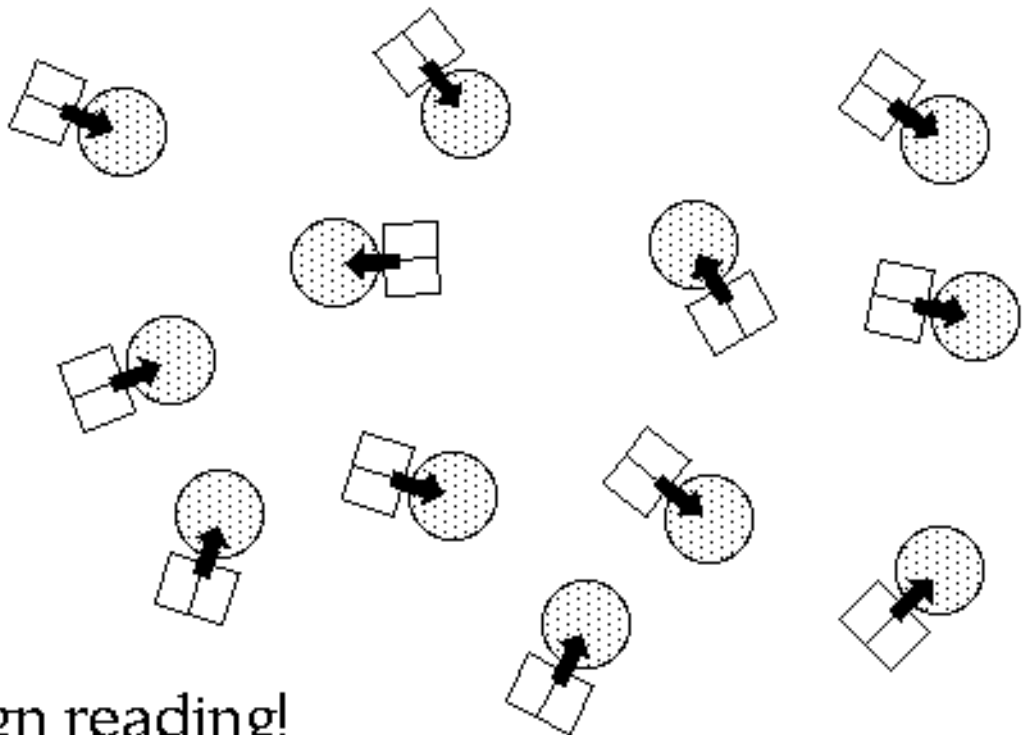


PEER INSTRUCTION

1. Recognize the inefficacy of the lecture method!



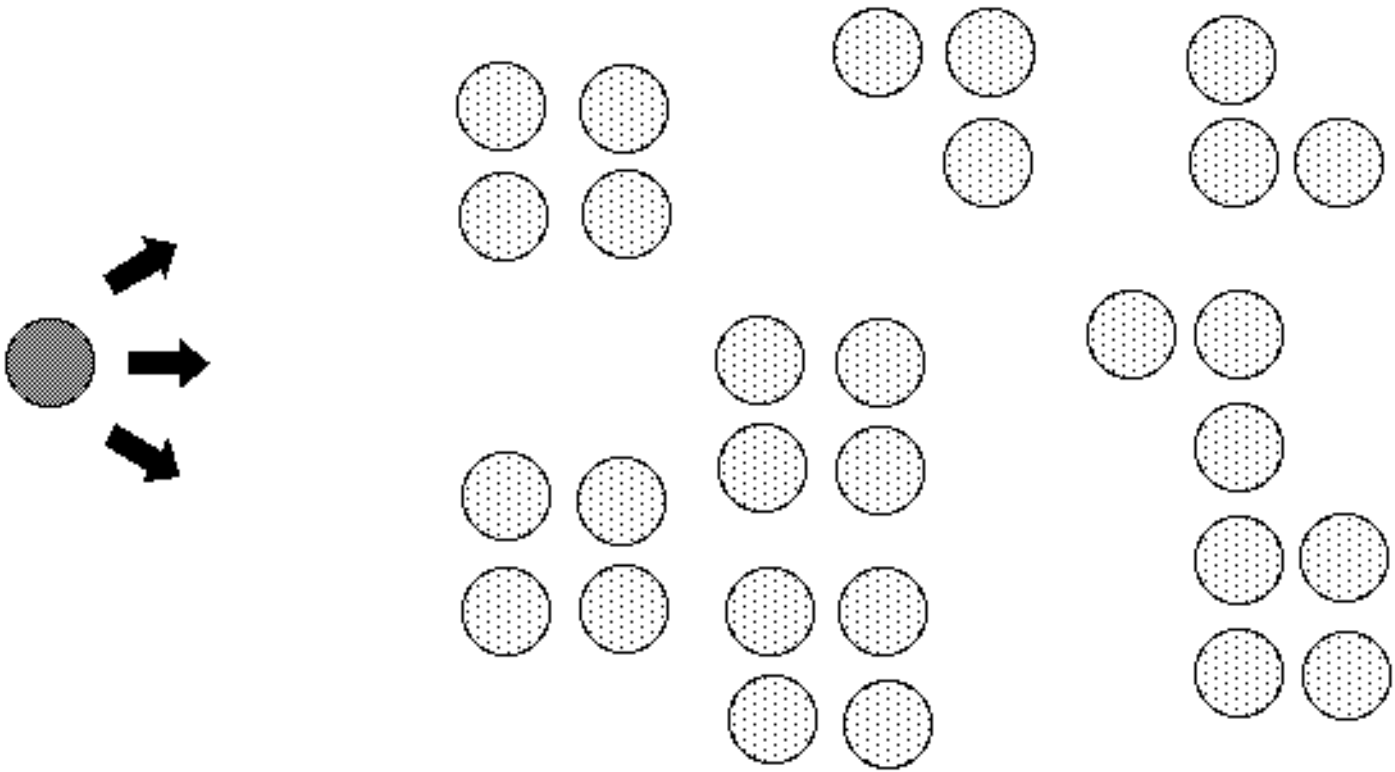
2. Move first exposure to material **out of classroom**



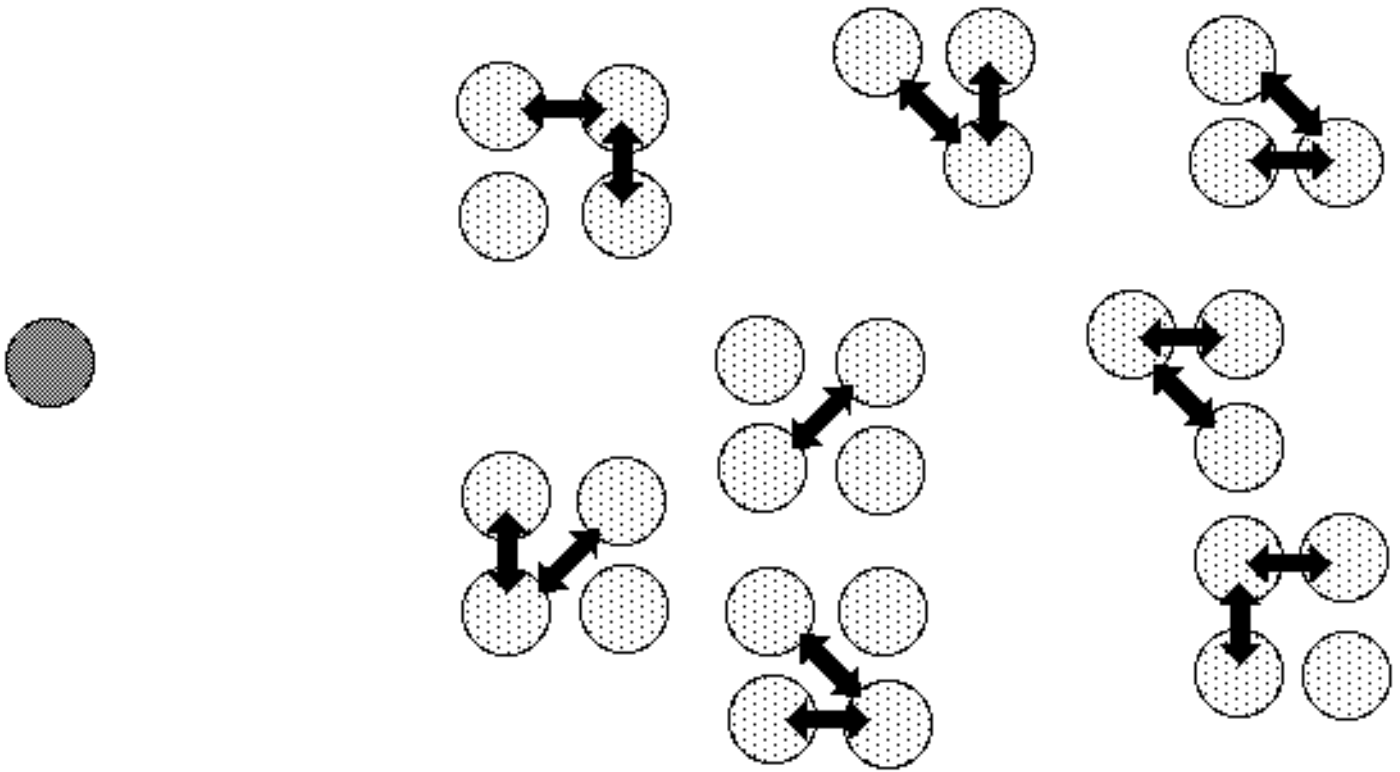
...assign reading!

3. Use class to deepen and broaden understanding

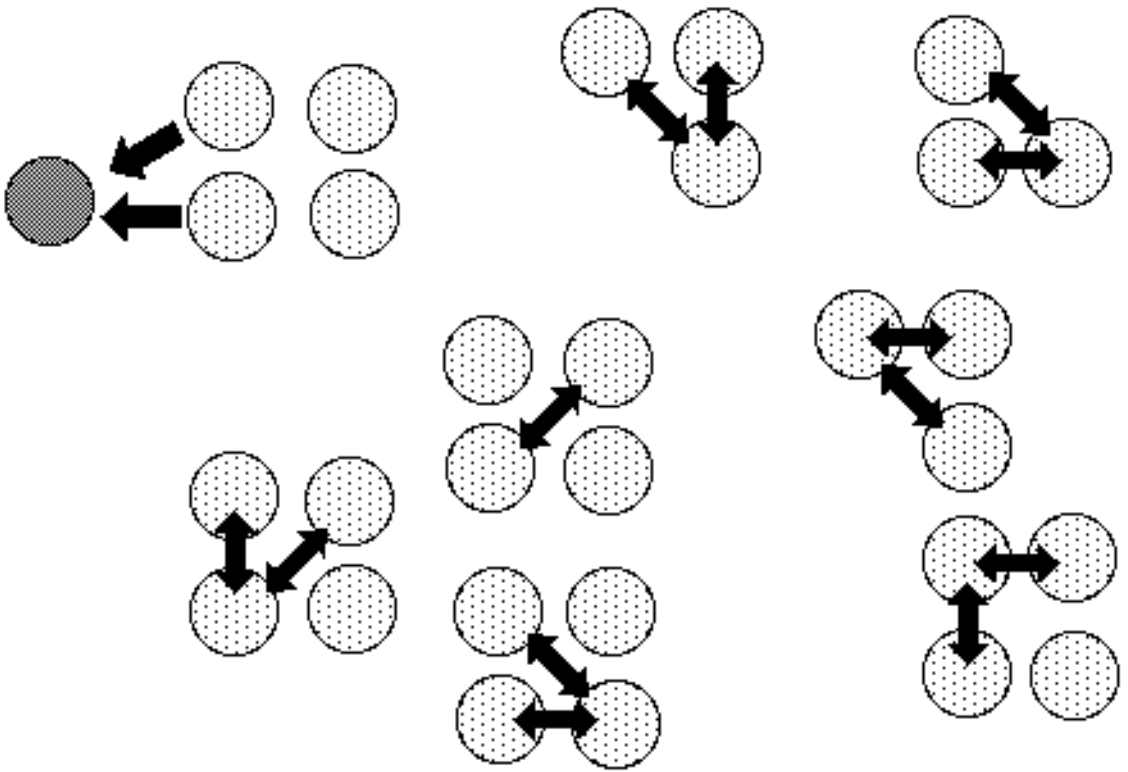
... by transferring some **additional** information ...



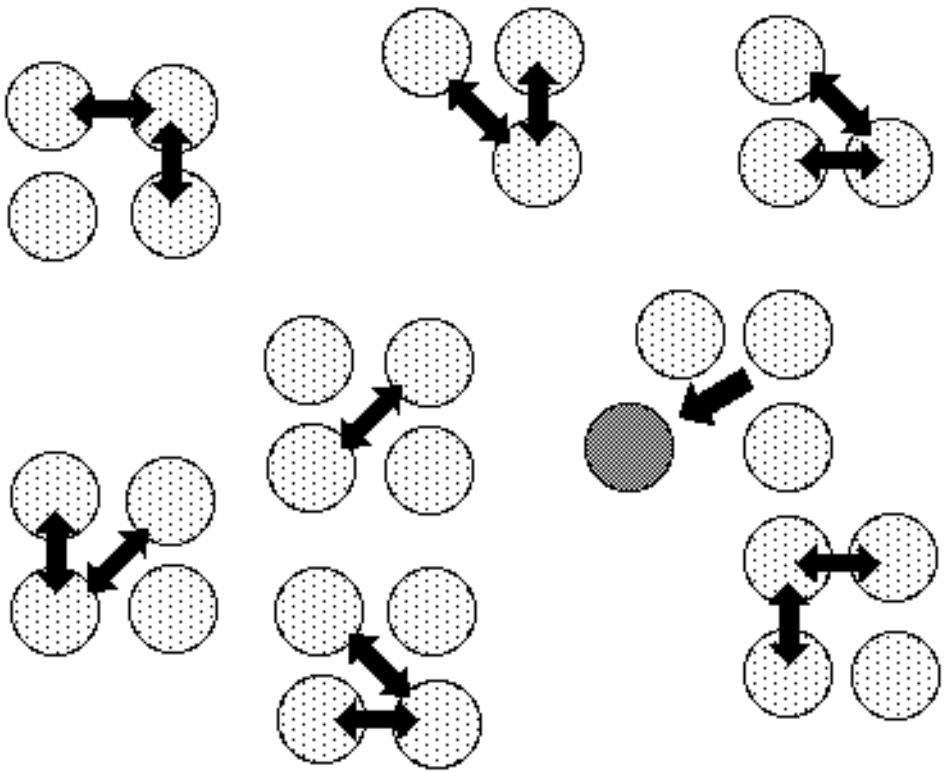
... and by giving students opportunities to **think**.



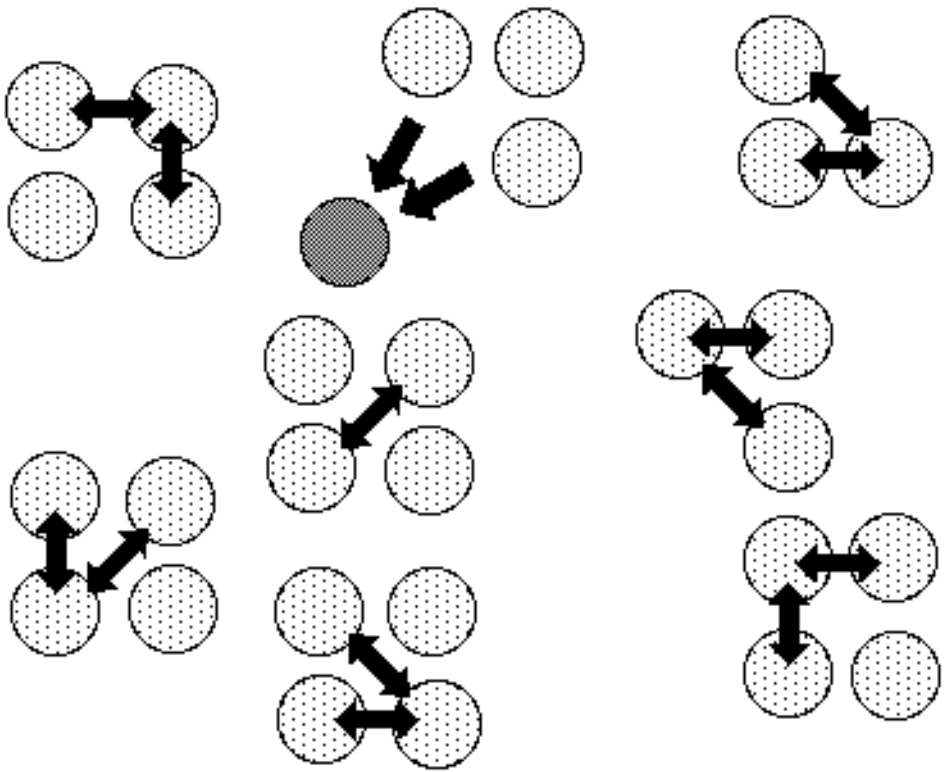
Better yet: **Learn** from your students ...



Better yet: **Learn** from your students ...

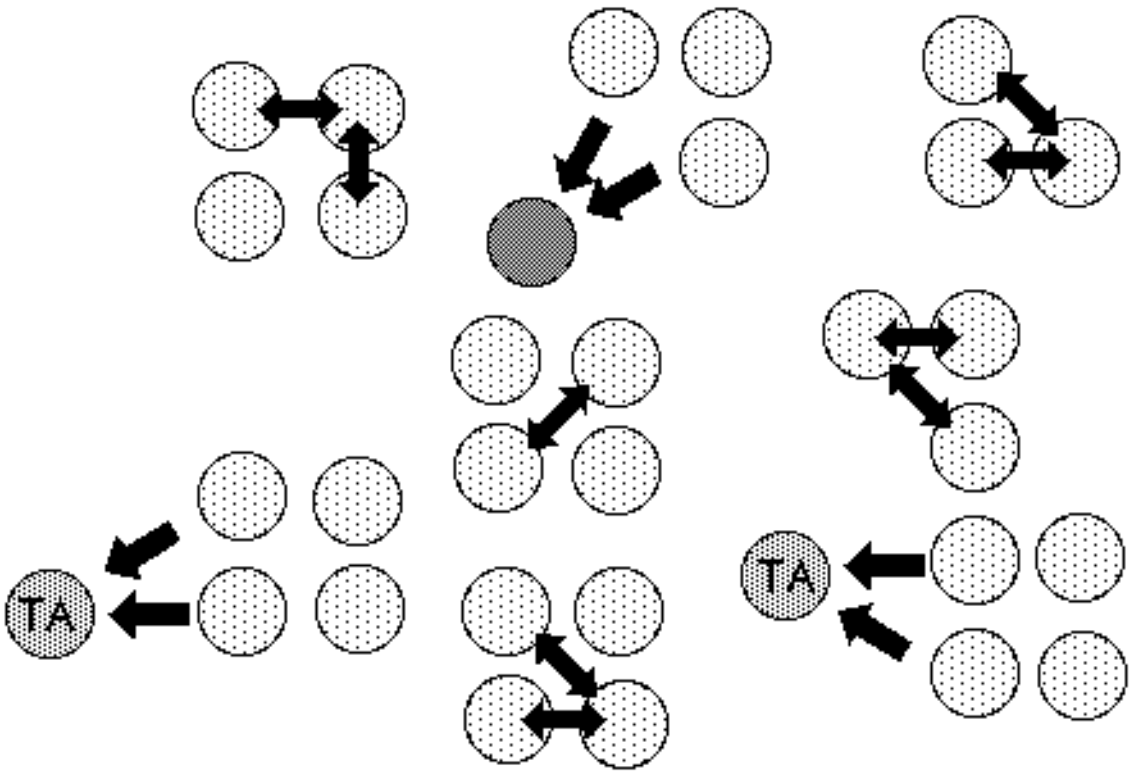


Better yet: **Learn** from your students ...



PEER INSTRUCTION

... bring in your **Teaching Assistants** too...!

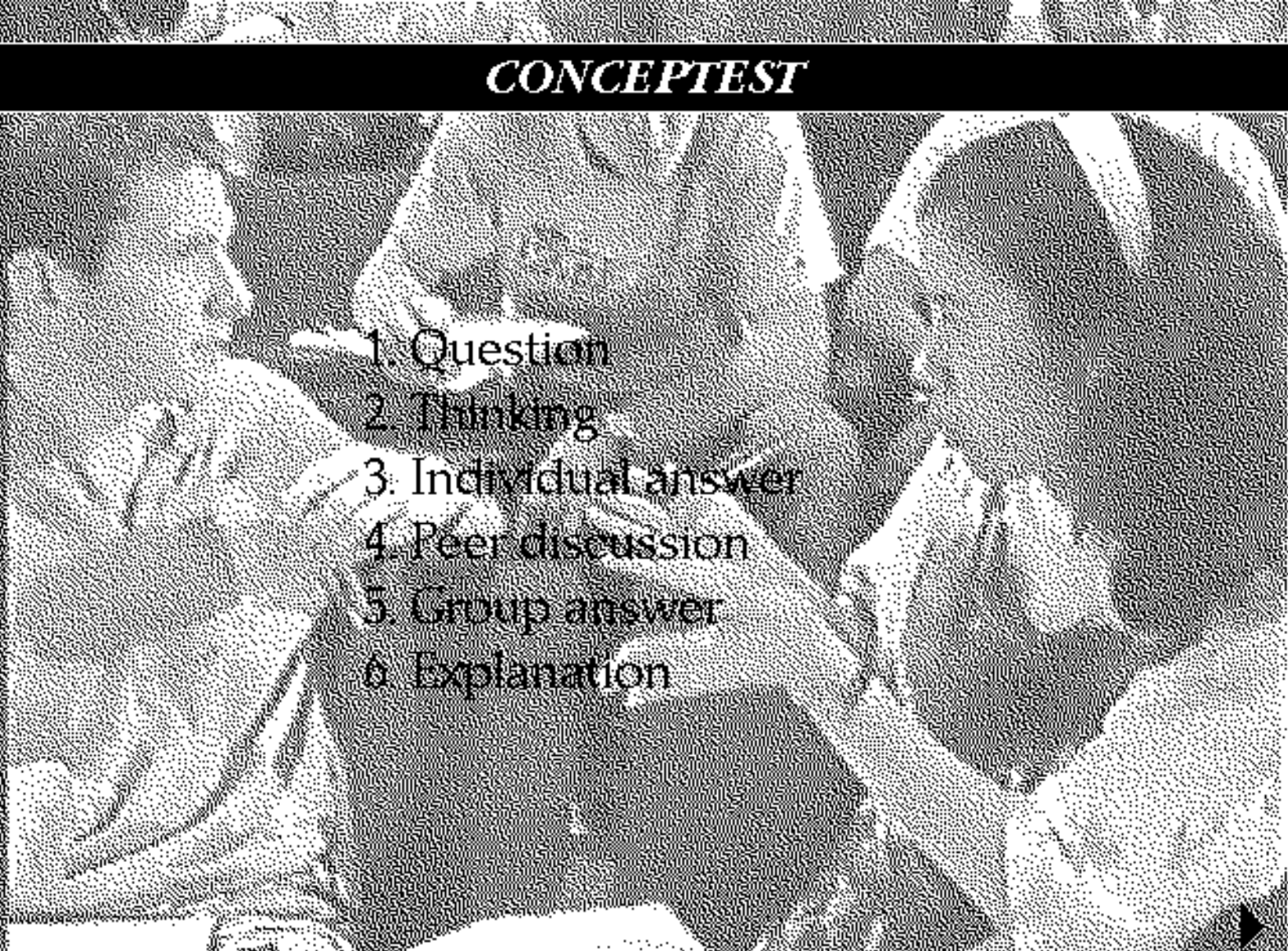


PEER INSTRUCTION

Main features:

- Pre-class reading
- In class: depth, not coverage
- ConcepTests

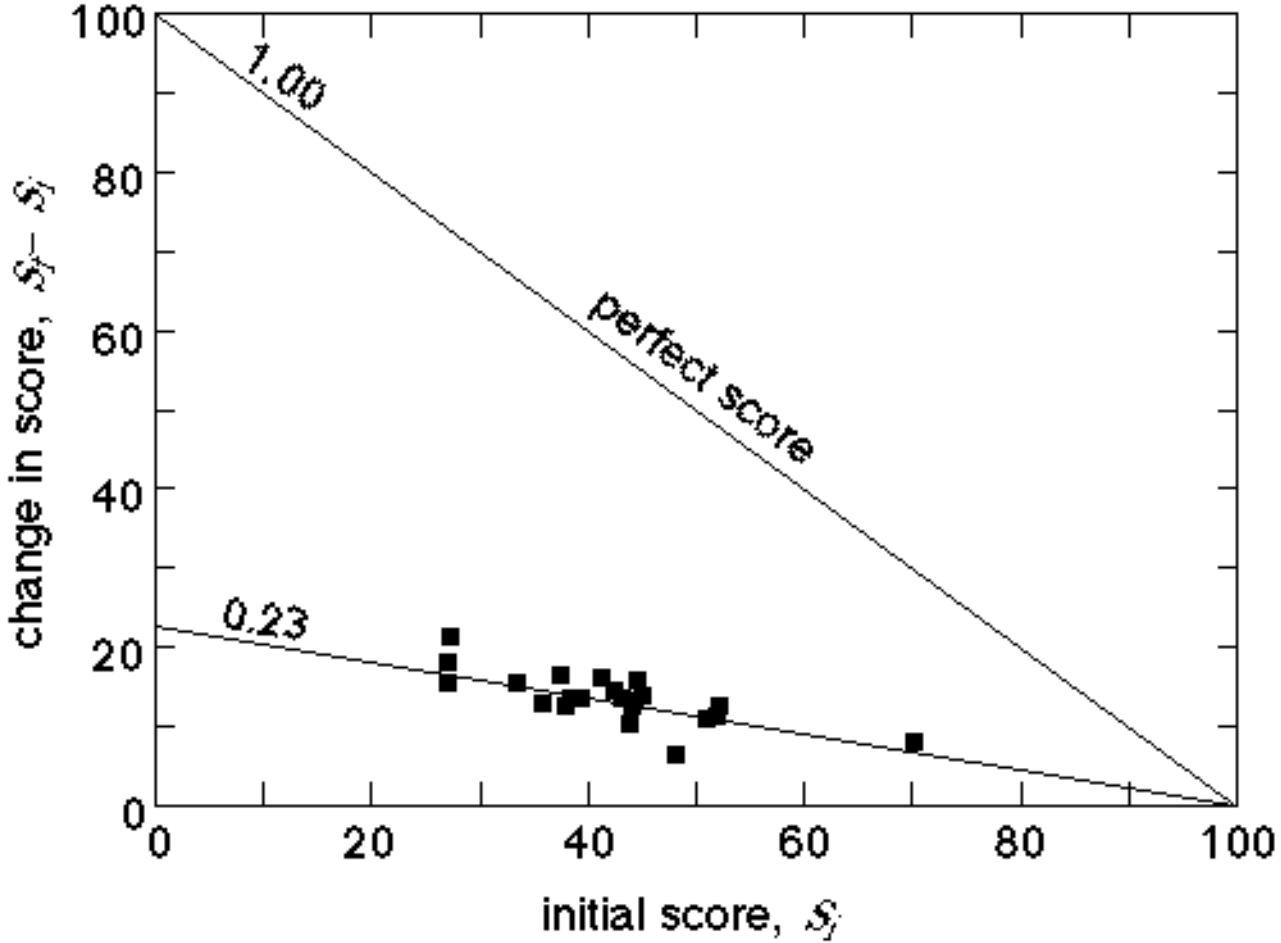
CONCEPTEST


1. Question
2. Thinking
3. Individual answer
4. Peer discussion
5. Group answer
6. Explanation

CONCEPTEST

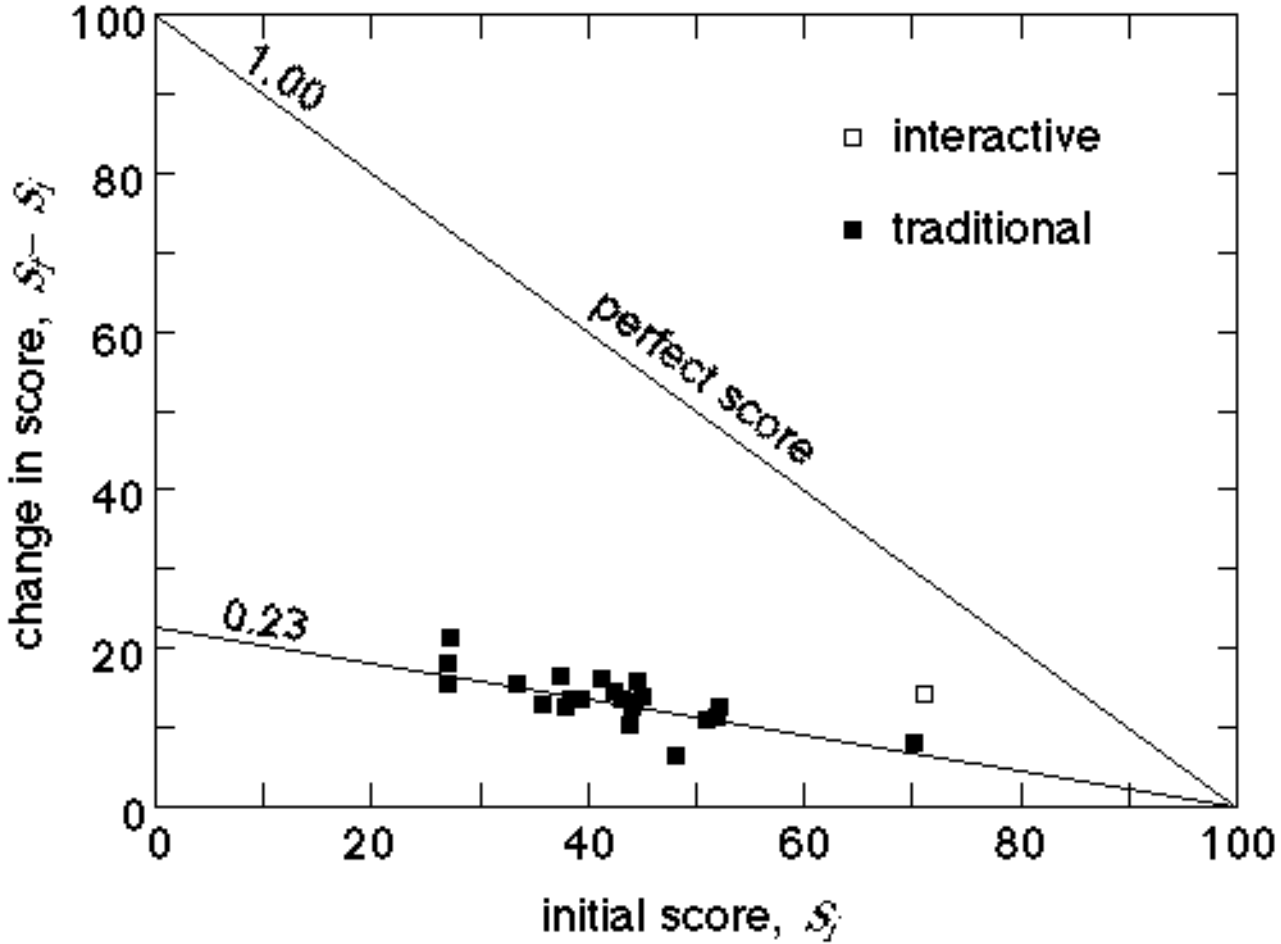
1. Results
2. Student reactions

RESULTS



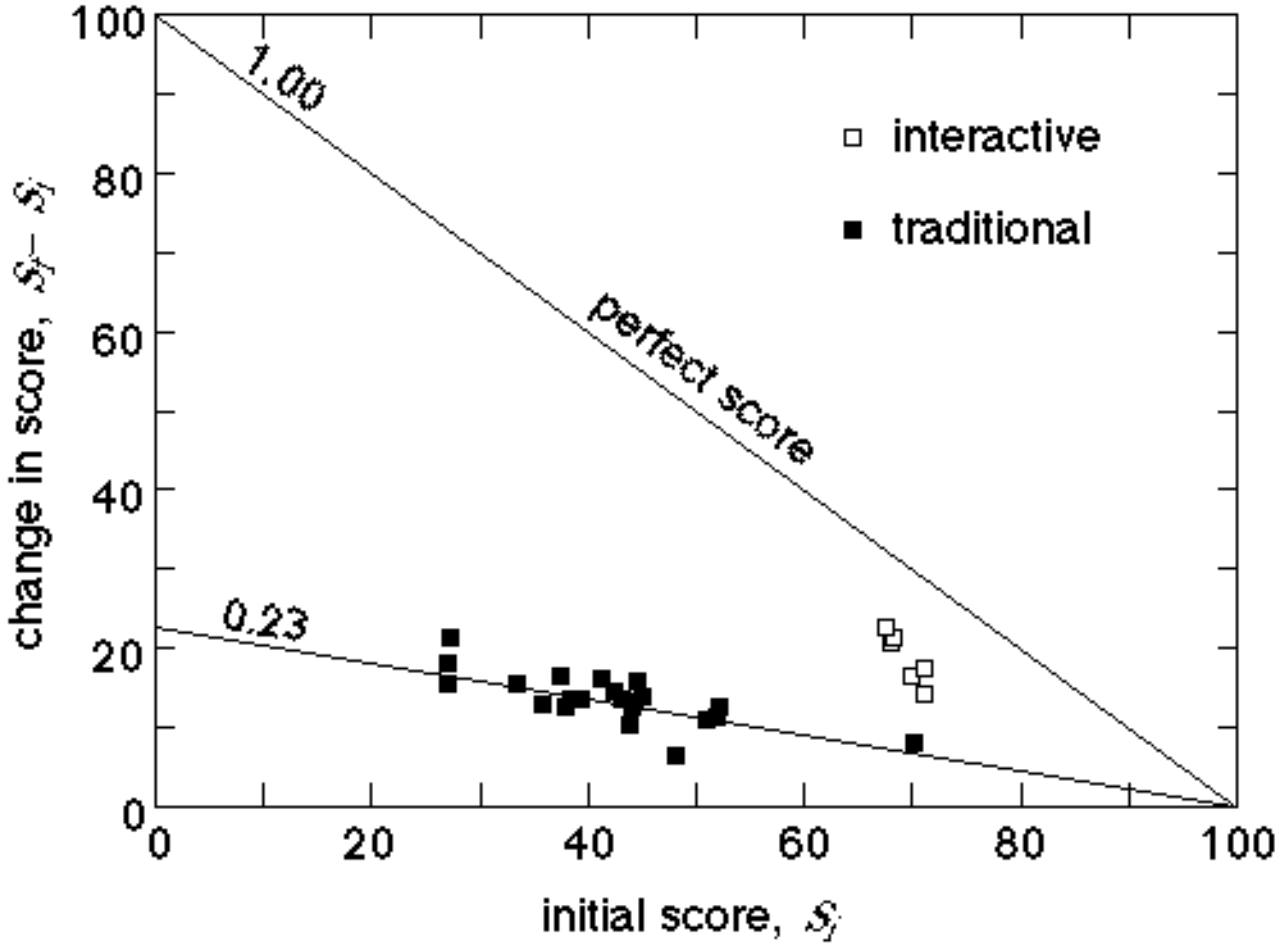
☞ Hake, AJP **66**, 64 (1998)

RESULTS



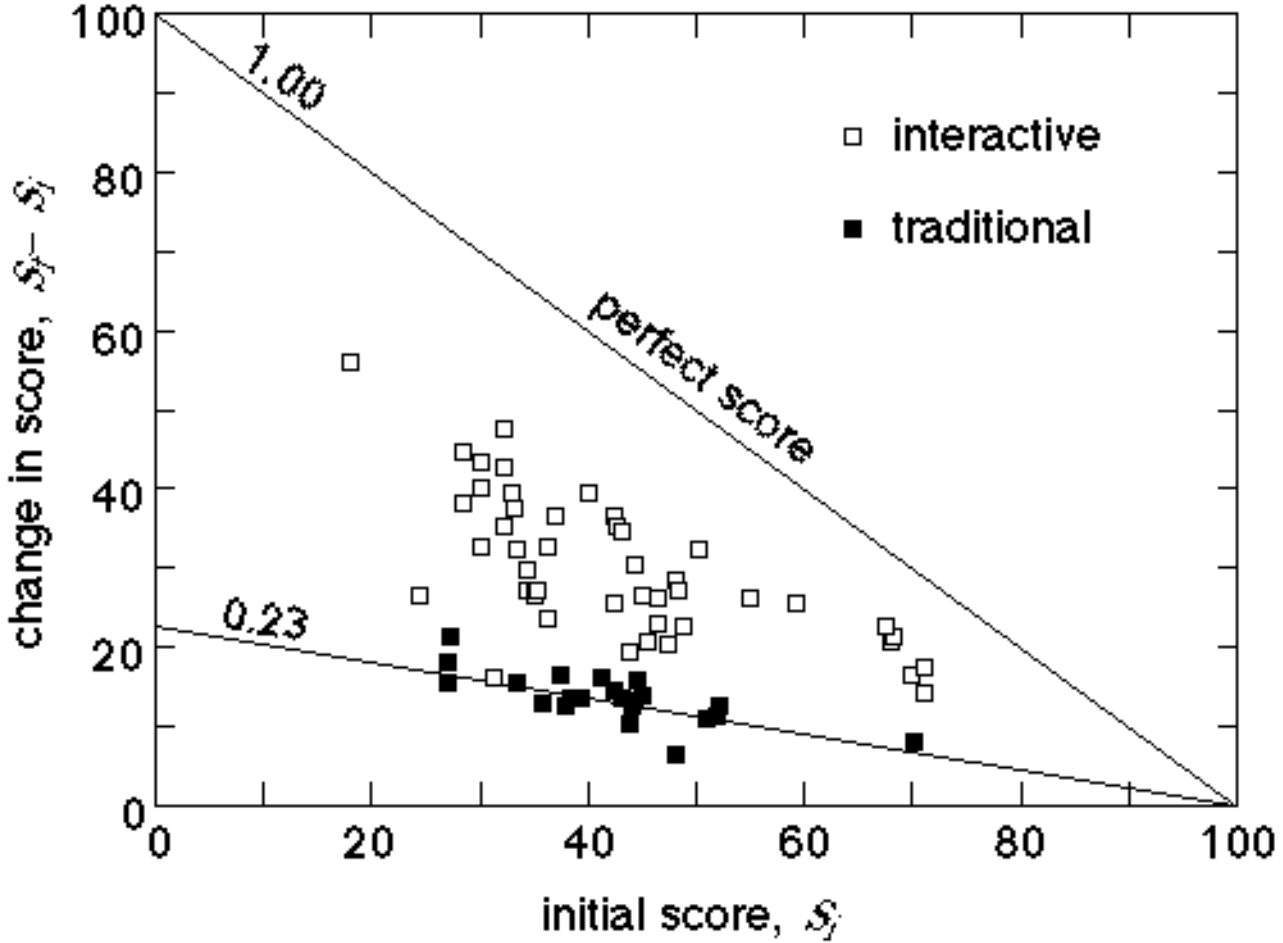
☞ Hake, AJP **66**, 64 (1998)

RESULTS



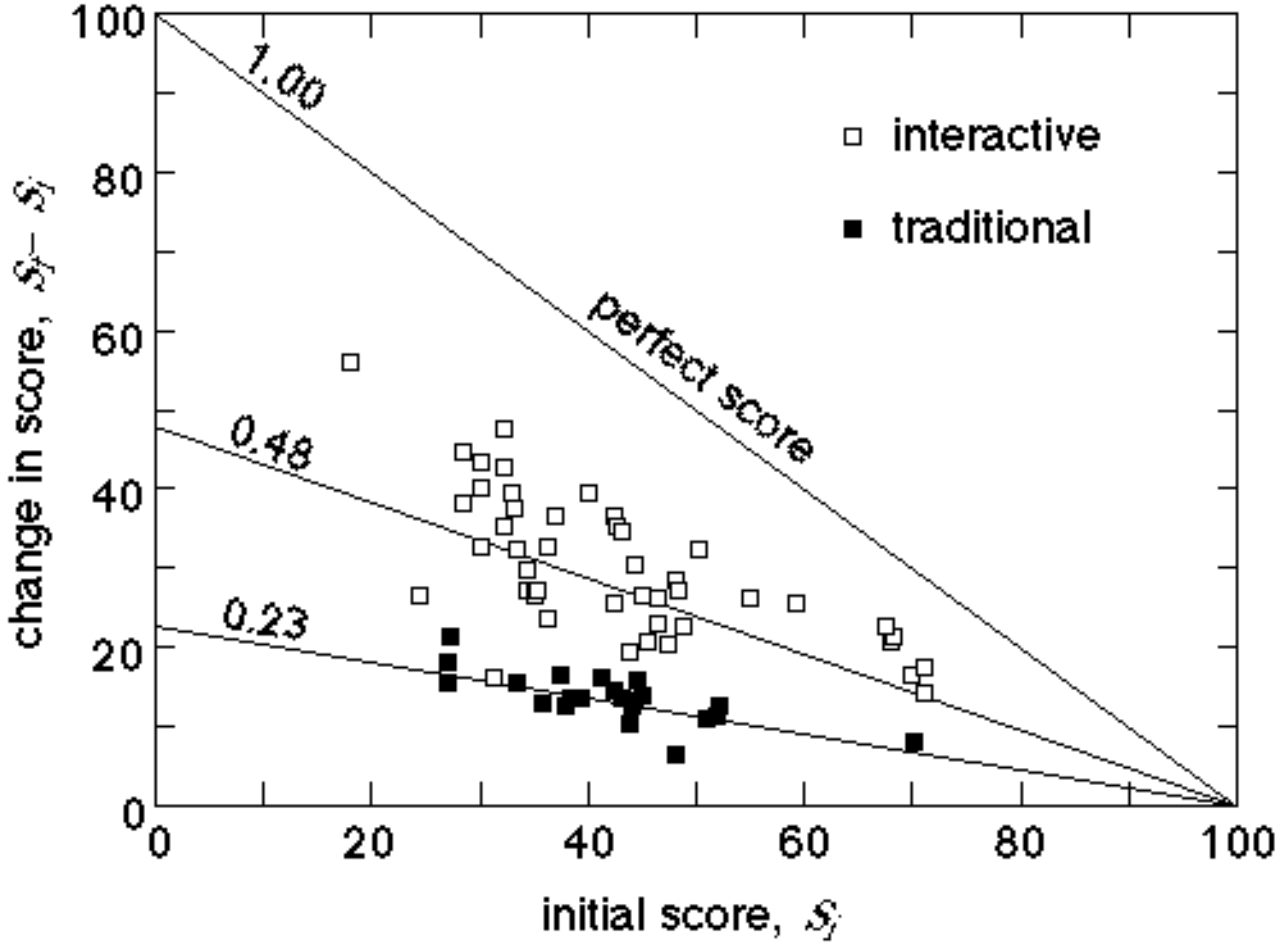
☞ Hake, AJP **66**, 64 (1998)

RESULTS



☞ Hake, AJP **66**, 64 (1998)

RESULTS

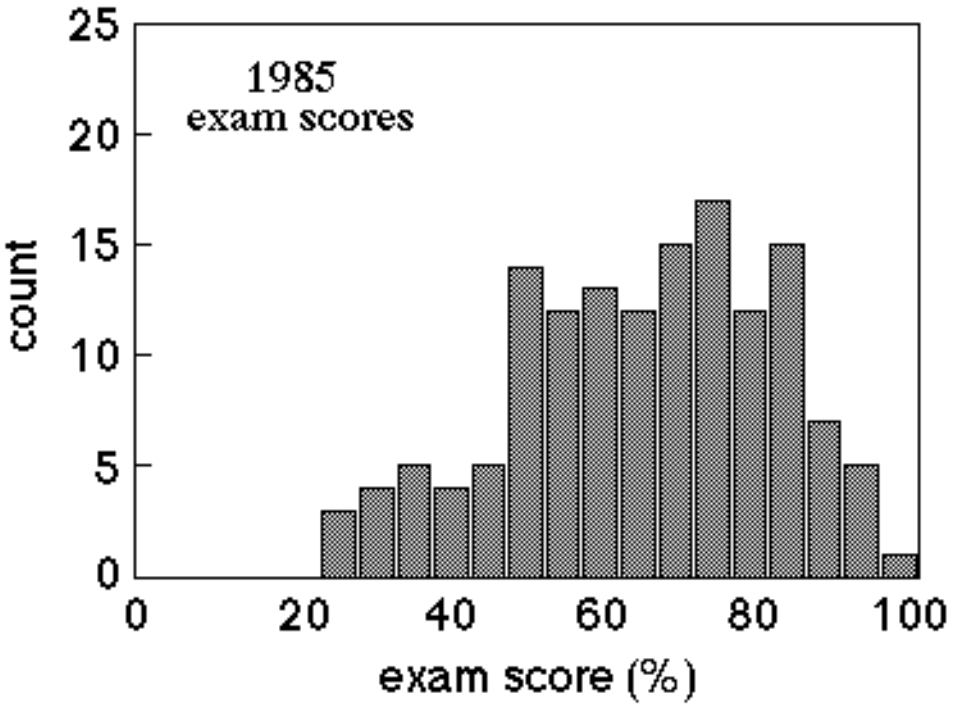


☞ Hake, AJP **66**, 64 (1998)

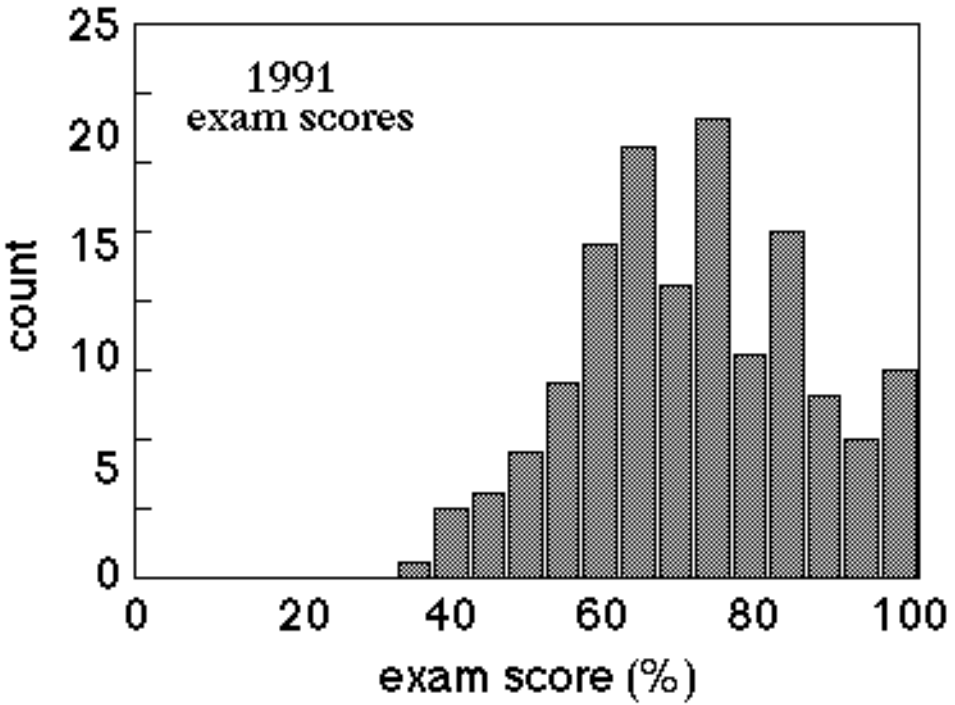
RESULTS

What about problem solving...?

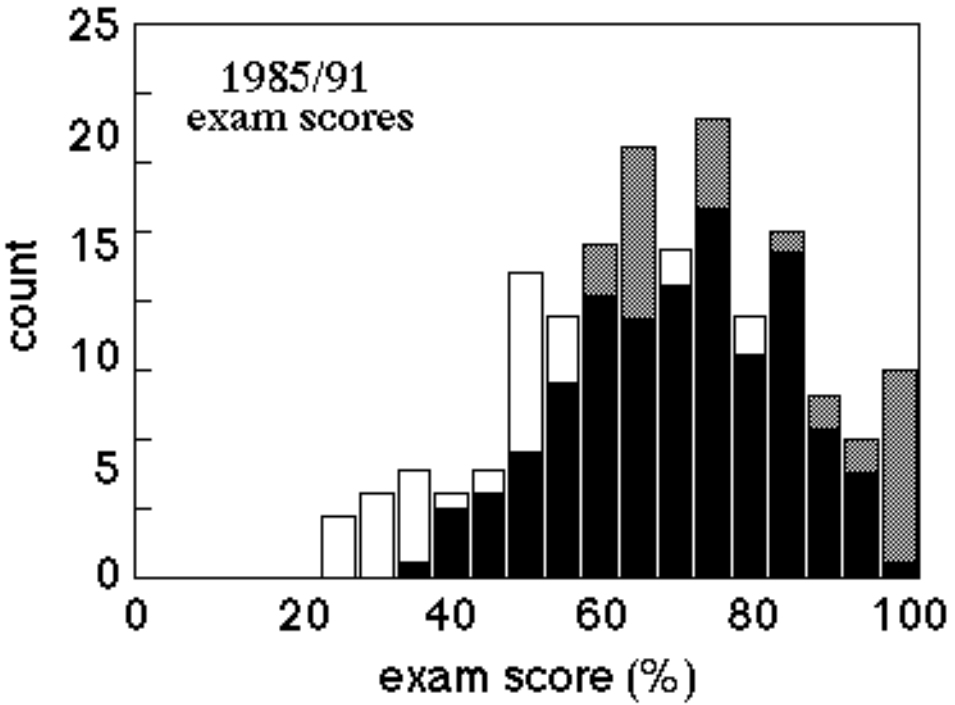
RESULTS


1985
exam scores
count
exam score (%)
0
5
10
15
20
25
0
20
40
60
80
100

RESULTS


1991
exam scores
count
25
20
15
10
5
0
0
20
40
60
80
100
exam score (%)

RESULTS


1985/91
exam scores
count
exam score (%)
0
5
10
15
20
25
0
20
40
60
80
100

RESULTS

So, better understanding leads to better problem solving ...

RESULTS

So, better understanding leads to better problem solving ...

(but "good" problem solving doesn't always indicate understanding!)

STUDENT REACTIONS

Why does it work?

Students:

- gets them thinking
- helps uncover misunderstandings
- boosts confidence

Faculty:

- change of format, not content
- with existing questions, little effort
- adaptable

Catherine Crouch (Harvard)
Deborah Alpert (Harvard)
Michael Aziz (Harvard)
William Paul (Harvard)
Tim Bozik (Prentice Hall)
David Hestenes (ASU)

Additional information:

http://galileo.harvard.edu