cience Education in the 21st Century; sing the tools of science teach science

Carl Wieman, Univ. of Colorado

I) The new importance of science education.

II) Research illuminating the problem.

III) Vision of the solution.

(Not medieval science, why medieval science education?)

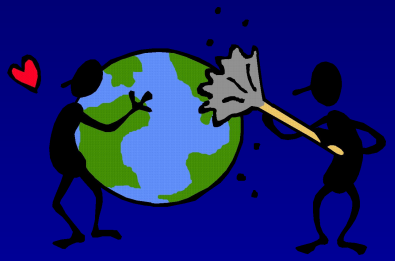
$$$ NSF, Kavli Found., CU

these slides have added references, not shown in original talk.

Science education more important, different purpose than in the past.

- Workforce in High-Tech Economy.

- Survival of world. *Wise decisions by citizenry on use of technology.*



- Educate large diverse fraction of population.
- Science education effective and relevant.

Essence of an "effective education".

Transform "novice" attitudes and problem solving approaches into "expert".

Think about science like a scientist.

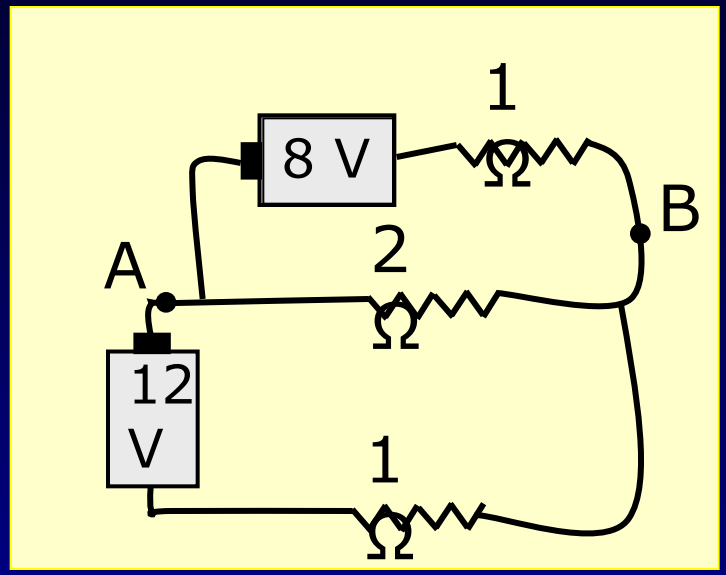
The state of affairs

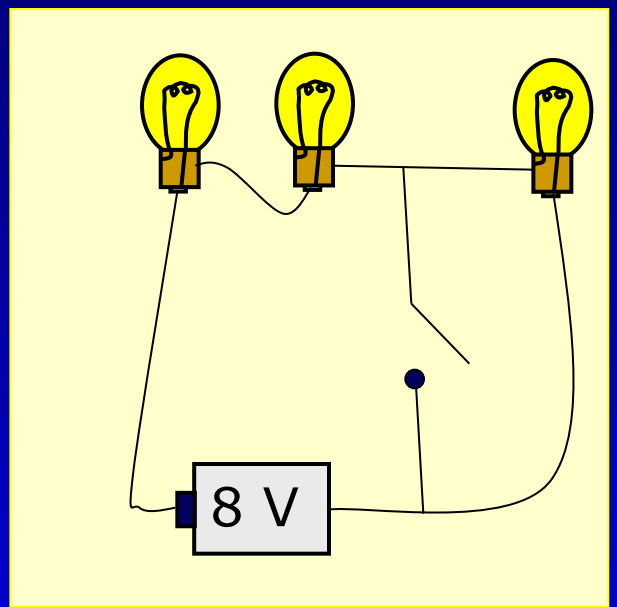
(mostly research from undergraduate physics)

1. Problem solving methods.

from E. Mazur, very popular, dedicated Harvard Prof. *ref. Peer Instruction, by E. Mazur Prentice Hall, 1997*

Most students could calculate voltages and currents in this fairly complex (to physicist) electrical circuit.





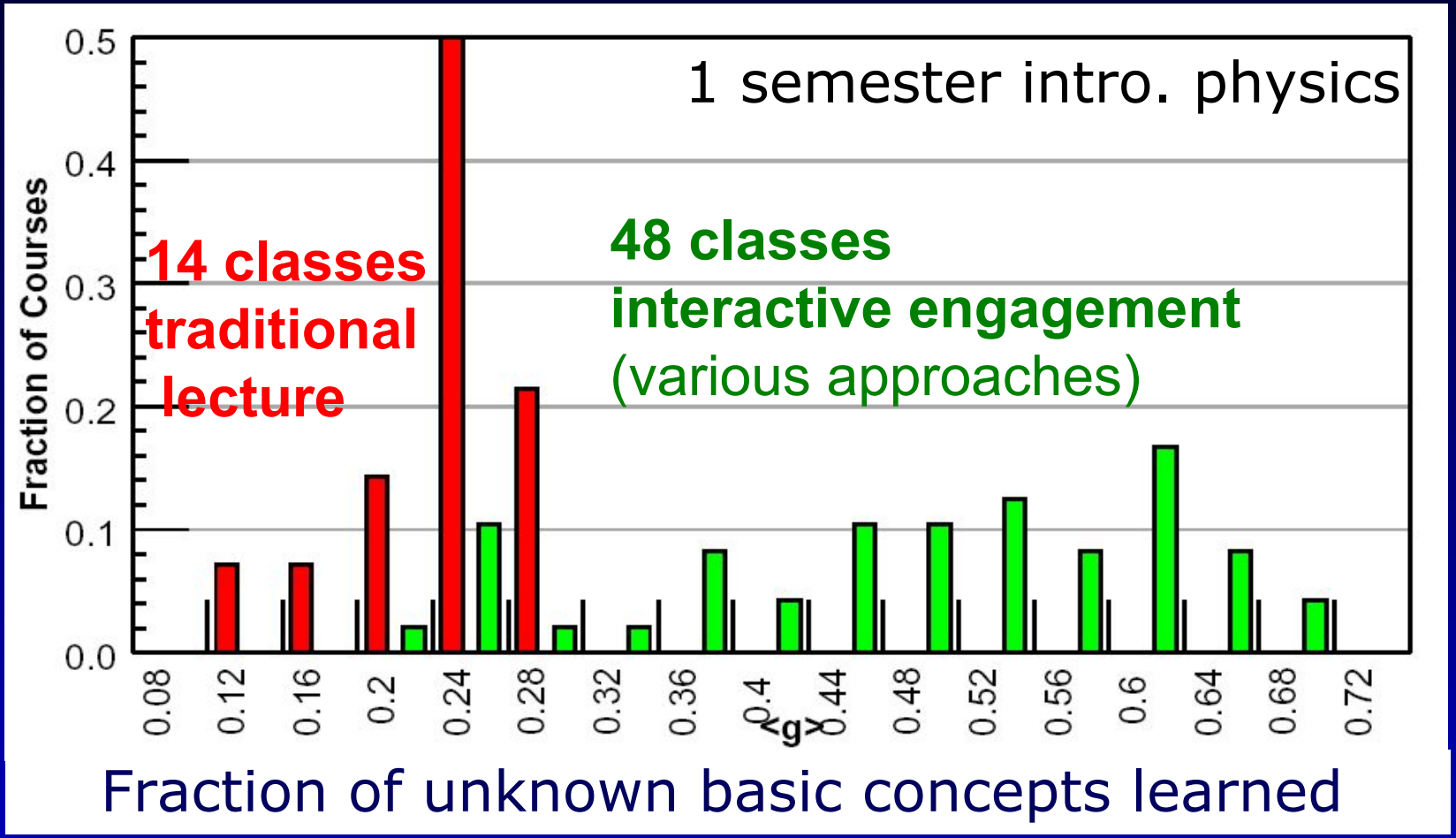
Ask same students what happens to brightness of light bulbs when switched closed. Embarrassingly simple (to physicist).

Most students could not do!!

2. Conceptual understanding

Concepts of force and motion -- *(FCI test)*

Ref. Hake, R. R. American Journal of Physics, 66, 64-74. 1998, see also Hake website



Independent of teacher quality.
Good and bad ways to teach science.

ref. Edward F. Redish, Richard N. Steinberg, and Jeffery M. Saul Am. J. Phys. 66, 212-224 (1998). Also Teaching Physics, Redish, Wiley, 2003, also CEW to be published,

3. Views of science and problem solving (*measured*)

Novice

Content: isolated pieces of information to be memorized.

Handed down by an authority.

Problem solving: pattern matching to memorized arcane recipes.

(boring, irrelevant)

Expert

Content: coherent structure of concepts.

Established by experiment, accessible to all.

Prob. Solving: Systematic concept-based strategies. Widely applicable.

traditional physics courses ⇒ *more* novice

, our unpublished stuff *including k-12 sci. teachers*

PE Research Conclusions:

- Faculty poor at knowing what students are (and are not) learning. *(precious little from lectures)*

- Most students "learning" memorization of facts and problem solving recipes. Useful only to pass exam.

(from undergraduate physics, but very likely true for teaching in other sciences, other levels)

Ref. Teaching Physics, E. Redish, Wiley 2003, and references therein

How to change?

Use tools of science to teach science!

- Practices and principles based on measurement, not tradition. *(meeting learning goals)*
- Effective use of technology. *(IT to measure and enhance learning)*
- Disseminate and build upon successful innovations.

why believe approach can work…

Clear examples of research-based teaching that work.
(*and are economically practical on large scale*)

- Collaborative problem solving/scientific discourse.

- Explicit focus on novice/expert attitudes and problem solving. ref. Redish book, CEW to be published

*Personal electronic response systems
to facilitate active thinking in classroom.
"clickers" ~ $20, individual student code.
Responses recorded and stored on computer.

ref. for unpublished discussions of installation and use of such clicker systems see
http://www.colorado.edu/physics/EducationIssues/HITT/HITTDescription.html
note we use HITT system, because at the time we were looking, they were least expensive, but there are now many other companies making such systems and they may well be as good or better. Data on use is from CEW and is unpublished.

Simple Example: clicker question for feedback to instructor on retention

"Sound you hear from a violin is produced …"

a. mostly by strings, b. mostly by wood in back,

c. both equally, d. none of the above.

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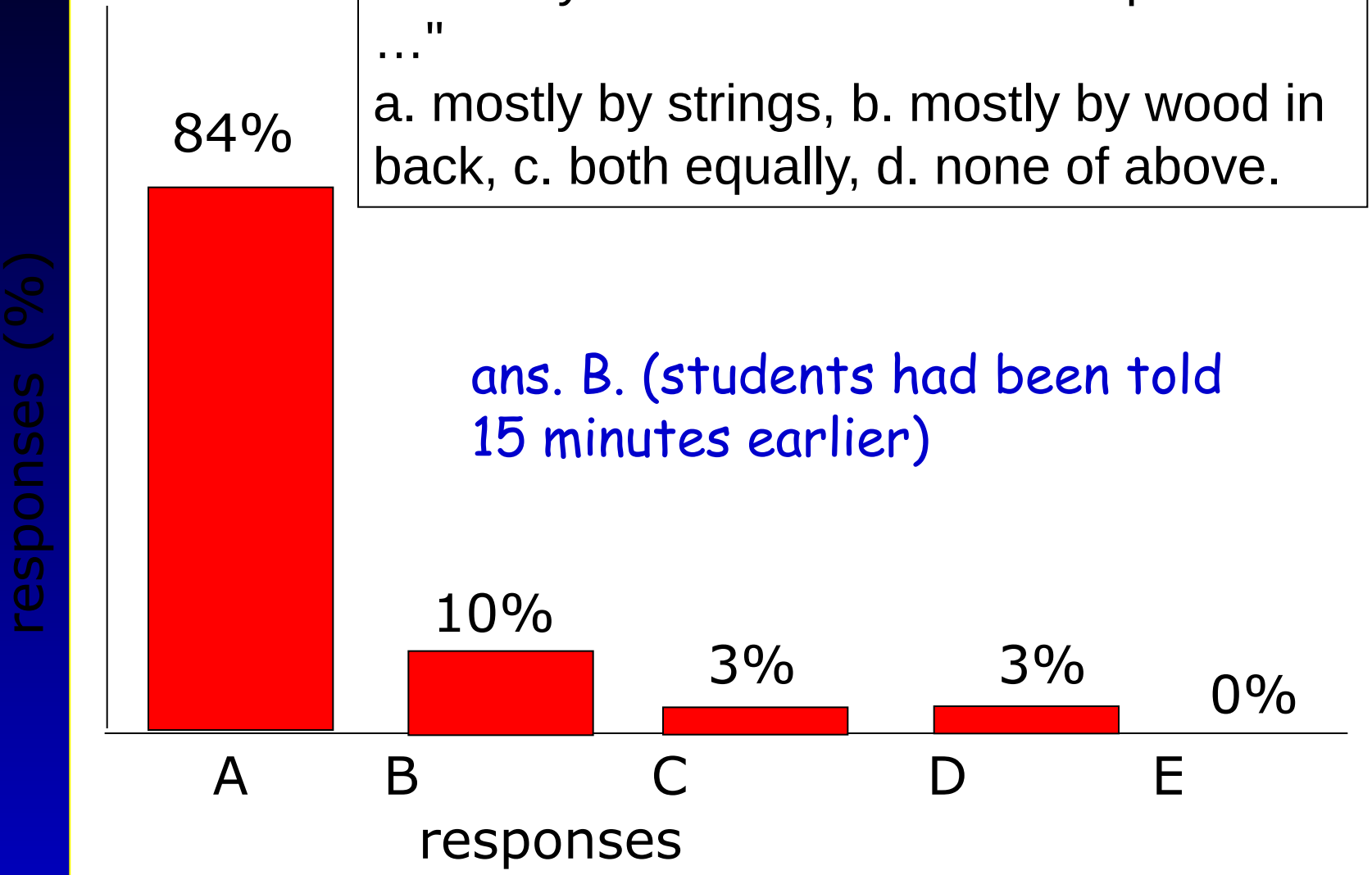


ans. B. (students had been told 15 minutes earlier)

Powerful combo: personal accountability, peer anonymity.

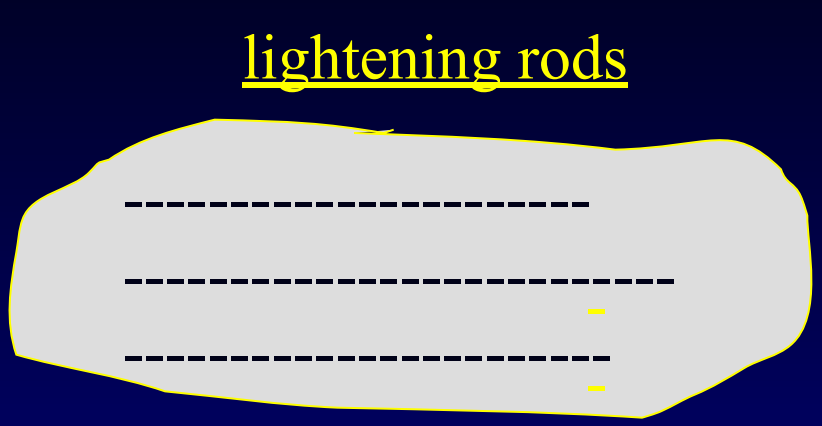
Used properly, transforms large classroom.
(small discussion group, consensus answers = examine reasoning)

1. Feedback to instructor.
2. Feedback to students.
3. Students engaged-- a dialogue.

Many more questions, particularly from women and minorities.
Develops critical thinking and articulation.
Much higher retention.

ref. CEW- to be published someday

Lesson built around clicker question.



Lightening rods
a. attract lightening to tip, prevent from hitting rest of building.
b. prevent lightening from occurring.
c. make it strike somewhere else.
d. don't actually do anything, are superstition.

first asked-- 8% correct.
Discuss reasoning, relate to concepts.

Two days later, asked again.
>90 % correct!!

Summary:

- Need new, more effective approach to science ed.
- Tools of science (research, technology, disseminate-duplicate-improve) can revolutionize science education, just as did science.

A challenge and an exciting opportunity