Sharing Experience and Educational Research

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Peer Instruction : Ten years of experience and results

Catherine Crouch & Eric Mazur
American Journal of Physics 69, 970, (2001)

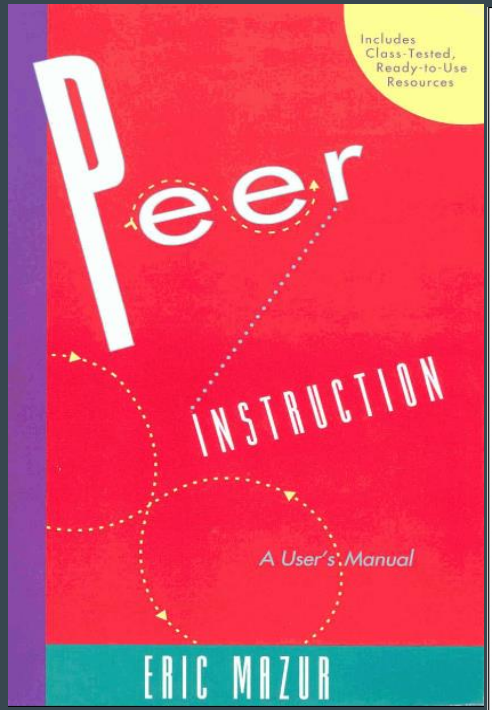
Peer Instruction: A user's manual

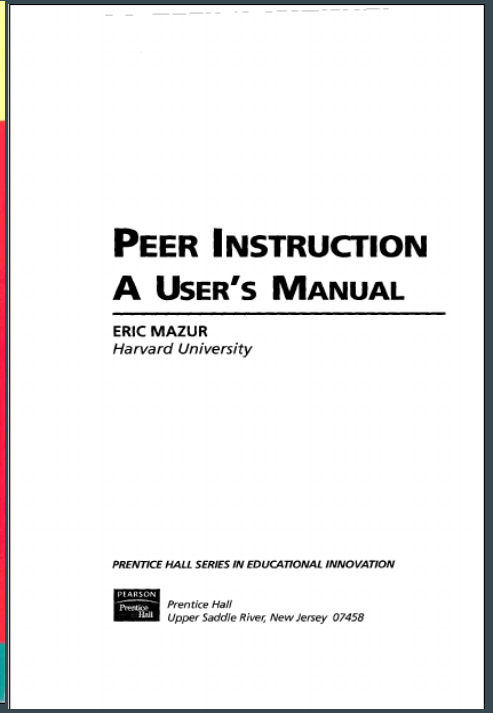
Eric Mazur
Prentice Hall (1997)

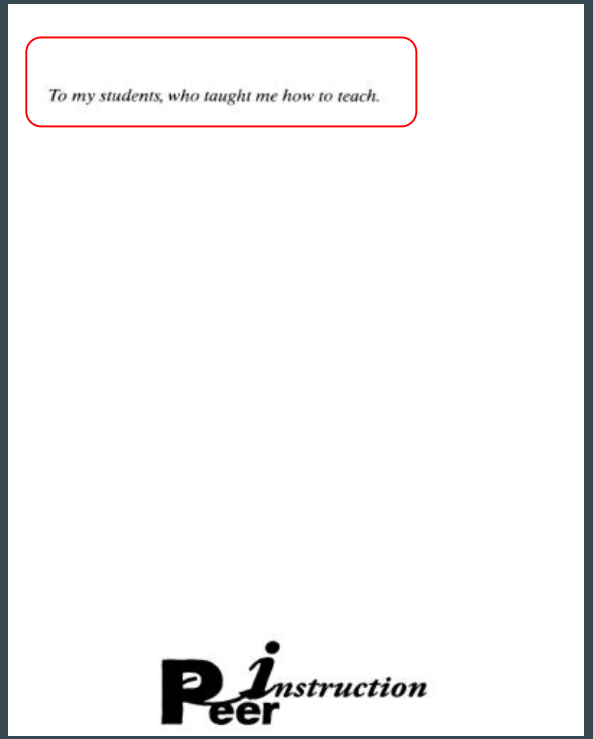
Outline

- Peer Instruction (PI)
- Implementation
- Ten years of results from Harvard
- Brief survey of PI from a range of classrooms
- Challenges and solutions

The Book


Includes Class-Tested, Ready-to-Use Resources
Peer
INSTRUCTION
A User's Manual
ERIC MAZUR


PEER INSTRUCTION
A USER'S MANUAL
ERIC MAZUR
Harvard University
PRENTICE HALL SERIES IN EDUCATIONAL INNOVATION
PEARSON Prentice Hall
Prentice Hall
Upper Saddle River, New Jersey 07458


To my students, who taught me how to teach.
Peer Instruction

Behind the book

Measure of Good Teaching

Eric Mazur
Balkanski Professor of Physics
Harvard University

- ❏ Teachers self-rating
- ❏ Students rating
- ❏ Students performance in solving difficult problems

The Eye Opener

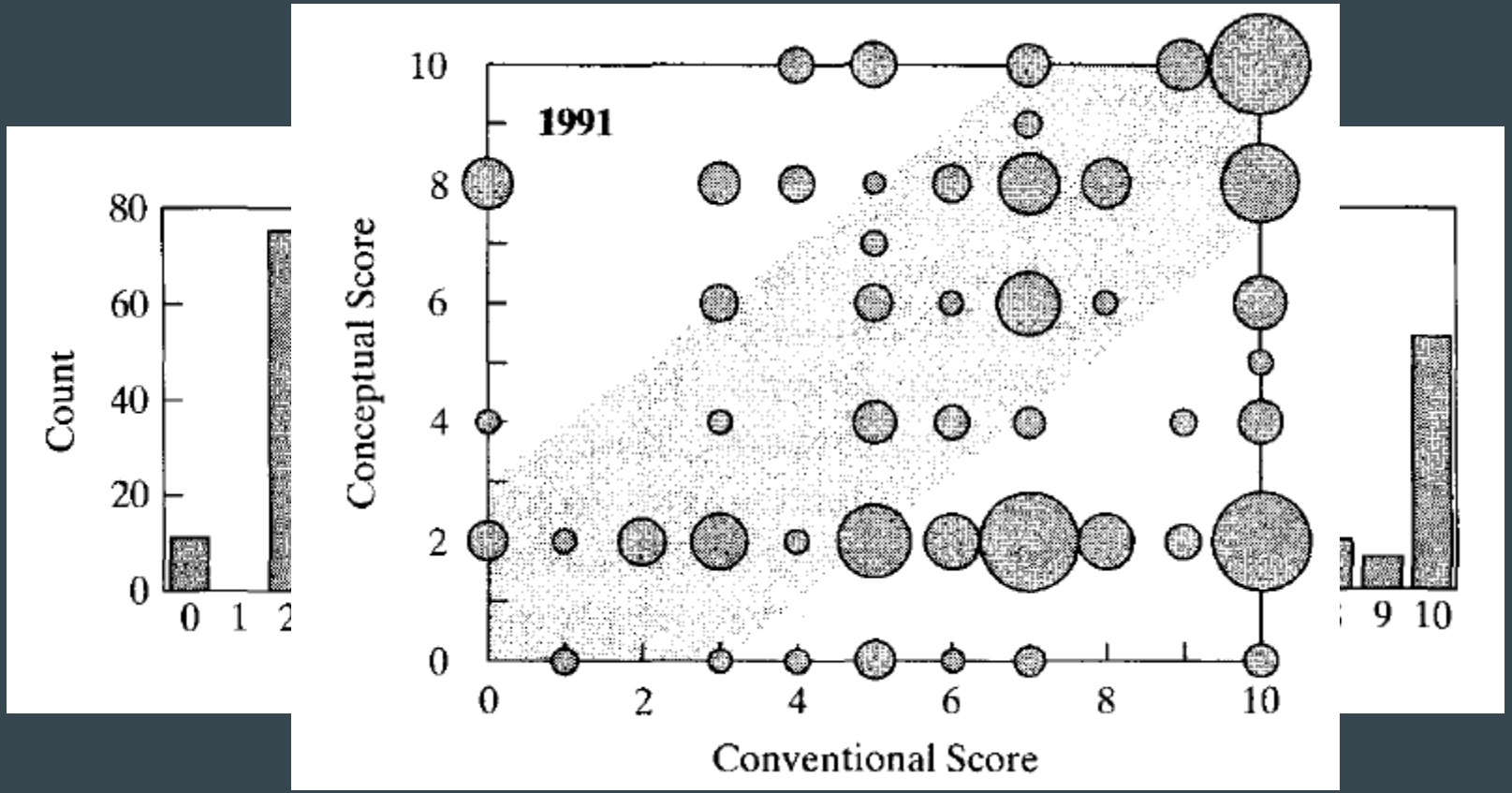
Eric Mazur
Balkanski Professor of Physics
Harvard University

Results in series of papers by Halloun & Hestenes, *Am J Phy*, 53 (1985), 55 (1987)

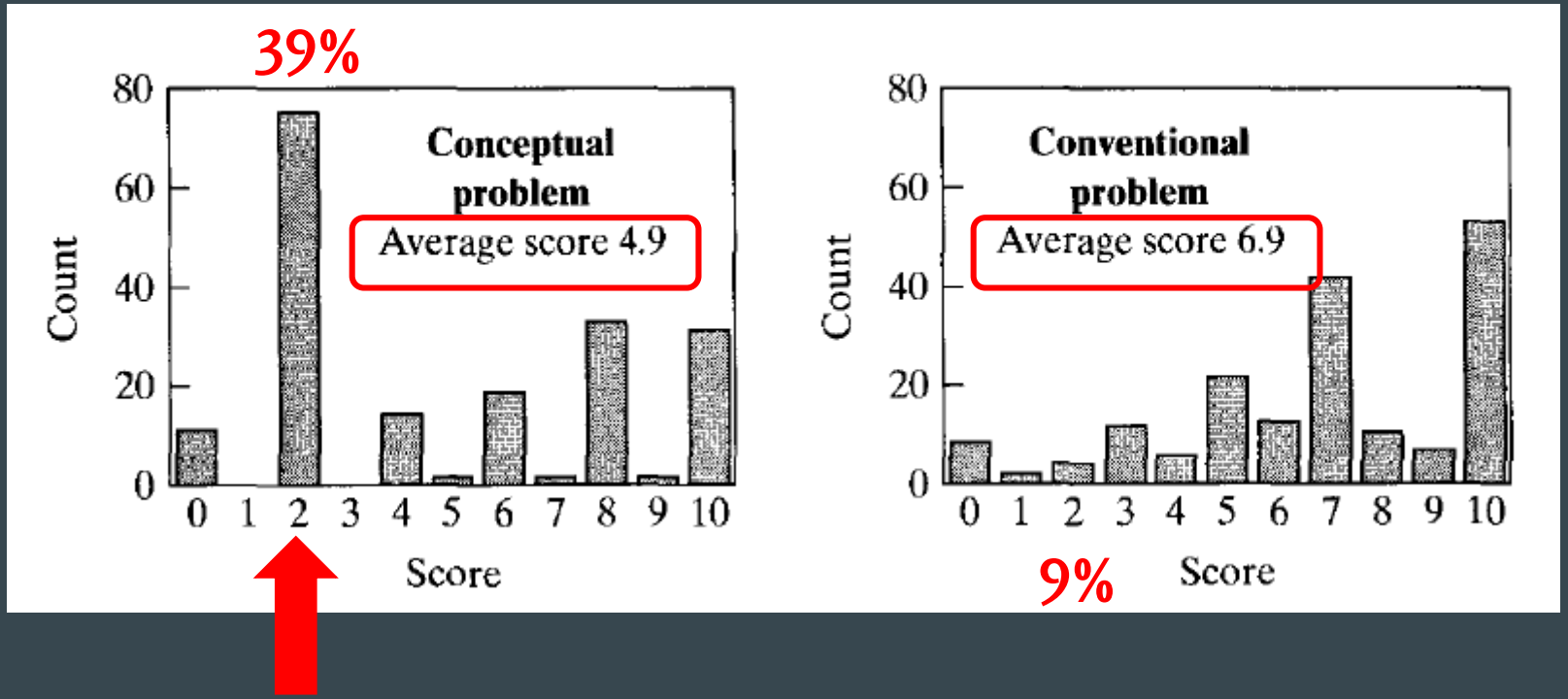
- Effect of instruction on change in common sense beliefs?
- **Example: When a heavy truck collides a car, which of the two exerts more force?**

Should I answer this question according to how you taught us or how I think about it?

Performance : Conceptual vs. Conventional Problems



Performance : Conceptual vs. Conventional Problems



Other Issues

- Limitations of “Problem Solving Strategies”
- Why lecture?

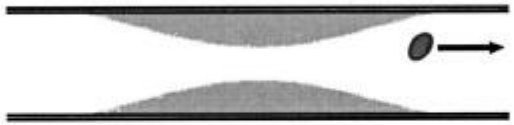
Peer Instruction

ConcepTest

Implementation of ConcepTest

- Question to students
- 1-2 min think and record answer (no discussions)
- 2-4 min convince your neighbours
  - Instructor strolls around, passive participation
- Record answers again
- Explanation of correct answer

A blood platelet drifts along with the flow of blood through an artery that is partially blocked by deposits.

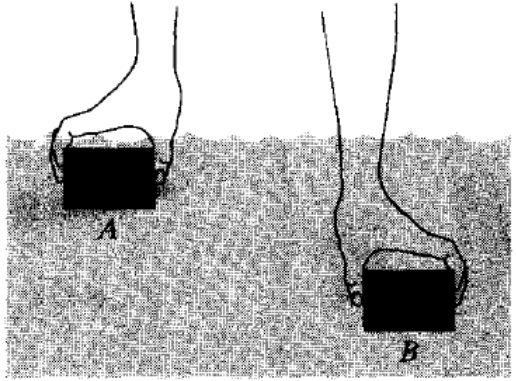


As the platelet moves from the narrow region to the wider region, its speed

1. increases.
2. remains the same.
3. decreases.

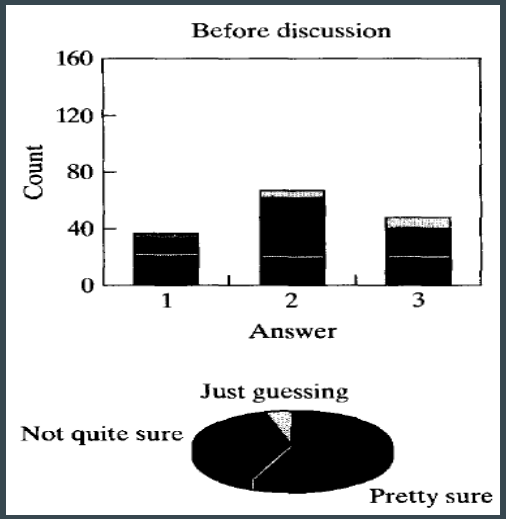
BUOYANCY

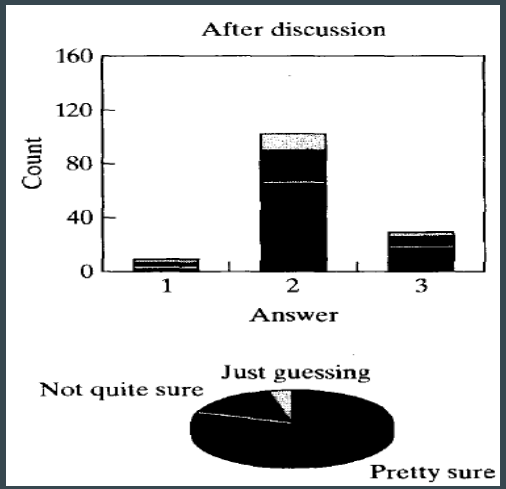
Imagine holding two identical bricks under water. Brick *A* is just beneath the surface of the water, while brick *B* is at a greater depth. The force needed to hold brick *B* in place is



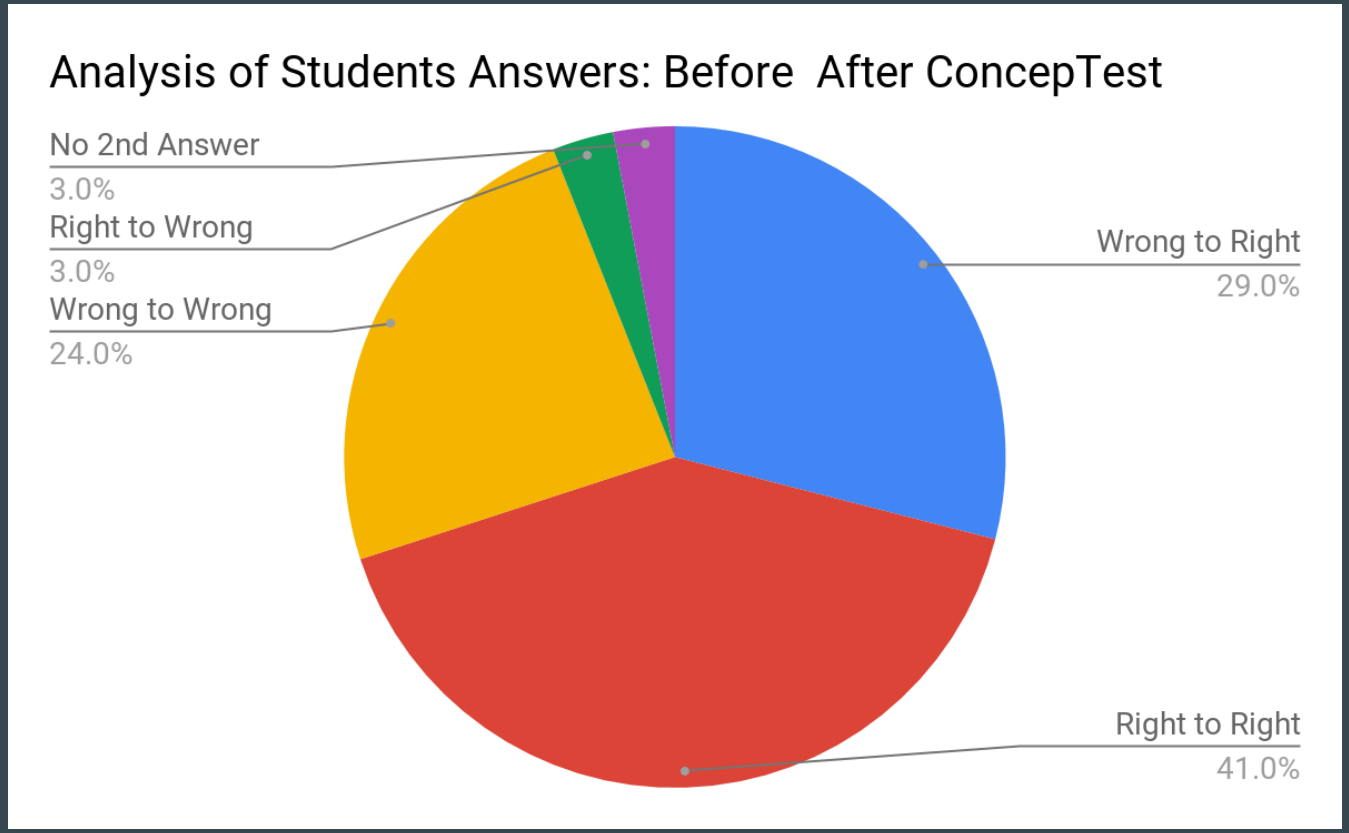
1. larger than
2. the same as
3. smaller than

the force required to hold brick *A* in place.

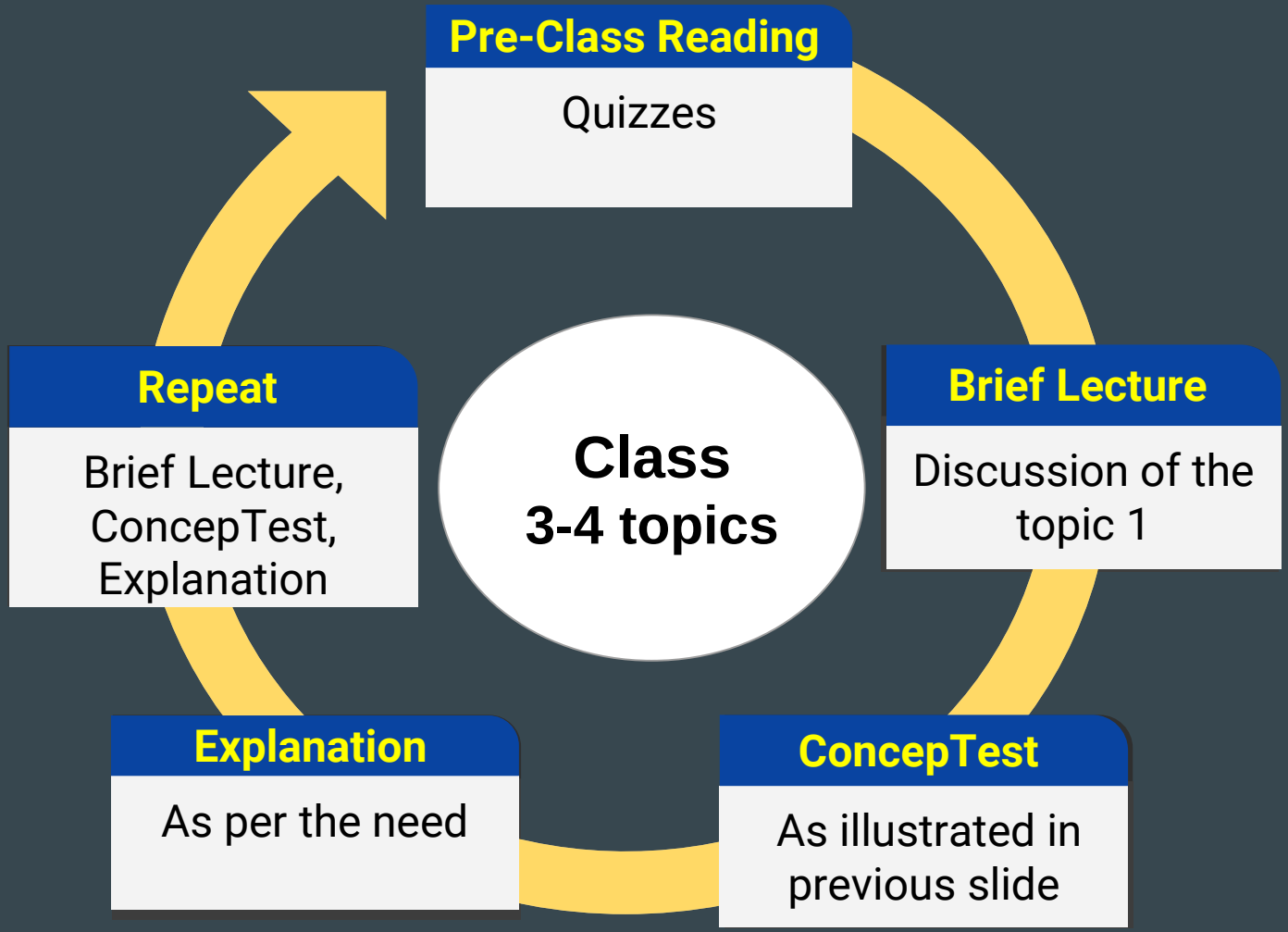




Peer Instruction, Mazur (1997)



Peer Instruction, Mazur (1997)


Pre-Class Reading
Quizzes
Brief Lecture
Discussion of the topic 1
ConcepTest
As illustrated in previous slide
Explanation
As per the need
Repeat
Brief Lecture, ConcepTest, Explanation
Class
3-4 topics

Pre-Class Reading

Reading Quizzes/Warm-up Exercises/Just-in-Time-Teaching Strategy

- ❏ Web-based assignment due before class
- ❏ Two questions probe difficult aspects of reading assignment
- ❏ **Third: "What did you find difficult or confusing about the reading? If nothing was difficult or confusing, tell us what you found most interesting."**
- ❏ Credit (5% of total) based on effort rather than correctness
- ❏ Help for instructor to prepare better

Peer Instruction: Ten years of experience and results

- Algebra and calculus based introductory physics
- Results of ten years
- Five instructors all of them with extensive experience of traditional lecturing
- **Measures of improvement**
  - Two standard tests (Force Concept Inventory, Mechanics Baseline Test)
  - Traditional exams, ConcepTests

Results

Conceptual Mastery

While the car, still pushing the truck, is speeding up to get up to cruising speed,

1. the amount of force with which the car pushes on the truck is equal to that with which the truck pushes back on the car.
2. the amount of force with which the car pushes on the truck is smaller than that with which the truck pushes back on the car.
3. the amount of force with which the car pushes on the truck is greater than that with which the truck pushes back on the car.
4. the car's engine is running so the car pushes against the truck, but the truck's engine is not running so the truck cannot push back against the car. The truck is pushed forward simply because it is in the way of the car.
5. neither the car nor the truck exerts any force on the other. The truck is pushed forward simply because it is in the way of the car.

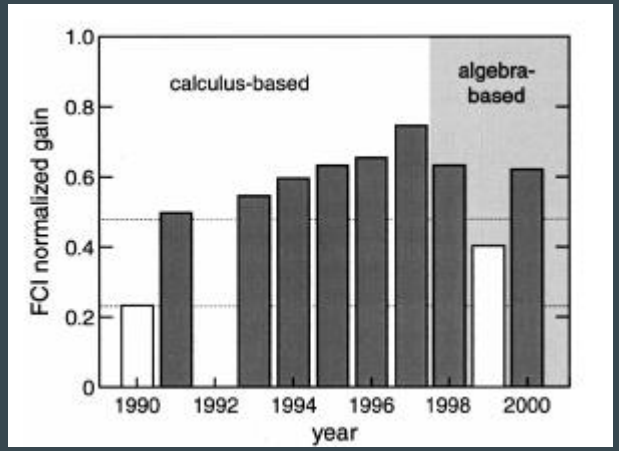
Conceptual Mastery

Force Concept Inventory

Table I. Force Concept Inventory (FCI) and Mechanics Baseline Test (MBT)

Year	Method	FCI pre	FCI post	Absolute gain (post−pre)	Normalized gain ⟨g⟩
Calculus-based					
1990	Traditional	(70%)	78%	8%	0.25
1991	PI	71%	85%	14%	0.49
1993	PI	70%	86%	16%	0.55
1994	PI	70%	88%	18%	0.59
1995	PI	67%	88%	21%	0.64
1996	PI	67%	89%	22%	0.68
1997	PI	67%	92%	25%	0.74
Algebra-based					
1998	PI	50%	83%	33%	0.65
1999	Traditional	(48%)	69%	21%	0.40
2000	PI	47%	80%	33%	0.63

$$\langle g \rangle = (\langle S_{post} \rangle - \langle S_{pre} \rangle)/(100\% - \langle S_{pre} \rangle)$$



Quantitative Problem Solving

A woman weighing 6.0×10^2 N is riding an elevator from the 1st to the 6th floor. As the elevator approaches the 6th floor, it decreases its upward speed from 8.0 to 2.0 m/s in 3.0 s. What is the average force exerted by the elevator floor on the woman during this 3.0-s interval?

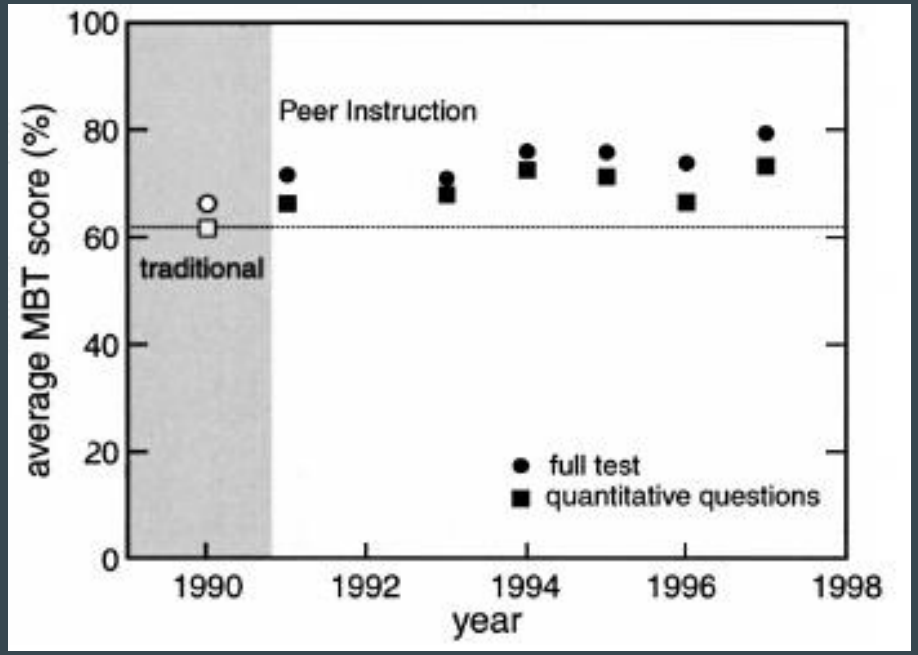
1. 120 N
2. 480 N
3. 600 N
4. 720 N
5. 1200 N

Quantitative Problem Solving

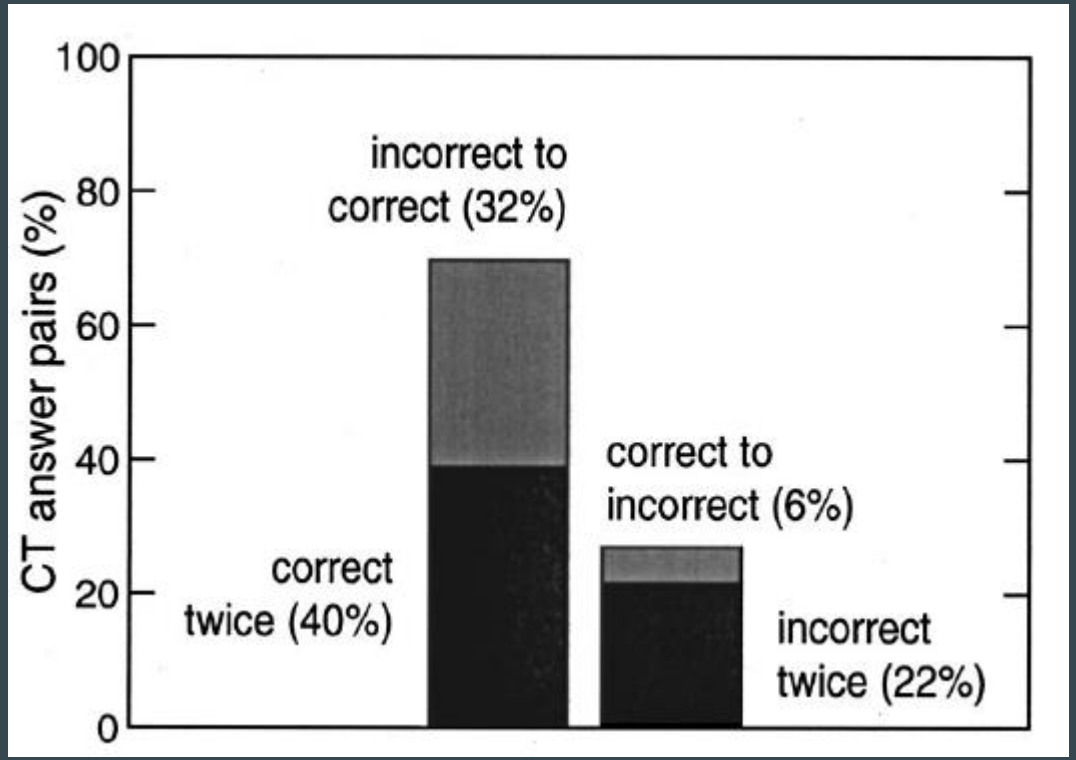
Year	Method	MBT	MBT quant. questions	*N*
Calculus-based				
1990	Traditional	66%	62%	121
1991	PI	72%	66%	177
1993	PI	71%	68%	158
1994	PI	76%	73%	216
1995	PI	76%	71%	181
1996	PI	74%	66%	153
1997	PI	79%	73%	117
Algebra-based				
1998	PI	68%	59%	246
1999	Traditional	...	...	129
2000	PI	66%	69%	126

Quantitative Problem Solving

Mechanics Baseline Test



ConcepTest Performance



The trade off

Concepts vs. Problem solving

Discussion Sections

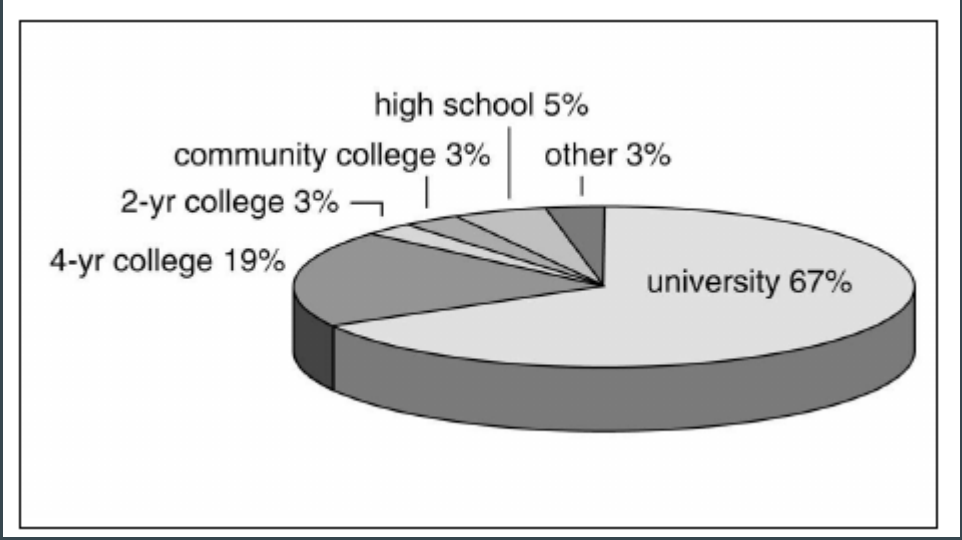
- ❏ Two hours weekly sessions
- ❏ Instructor solves a problem
- ❏ Students work in groups on selected problems
- ❏ Instructor helps through difficulties
- ❏ Students submit homework at the end of the week

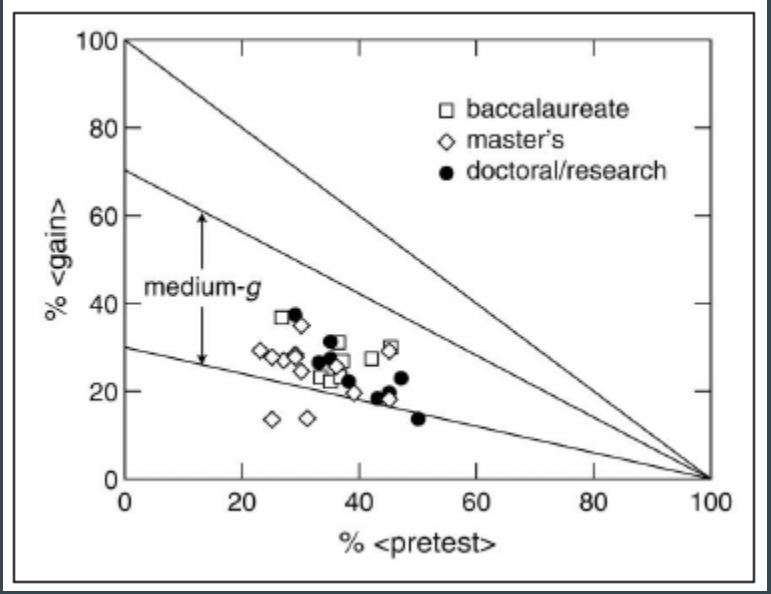
Peer Instruction: Results from a range of classrooms

Adam Fagen, Catherine Crouch & Eric Mazur

The Physics Teacher, 40 (2002)

- ❏ Web-based survey
- ❏ 2700 instructors
- ❏ 384 use PI
- ❏ From US and around the world
- ❏ Different subjects, sciences, engineering, humanities





$$g = \frac{S_f - S_i}{1 - S_i}$$

Challenges and Solutions

Often Asked Questions (Epilogue, PI, Mazur)

- Why bother?

  “Do we want our students to understand the basic principles, or are we satisfied if they can use formulas to solve numerical problems (even if close to half of them don't understand the underlying principles)?"

- Won’t we be forced to cover less if the students spend time talking to each other during the class?

- PI may work for Harvard students, but it won’t work for the students in my institution.

Often Asked Questions

- I don’t think I could use PI. I don’t have the right personality to do this sort of thing.

- Does this way of lecturing constitute what we call teaching?

- How much work is required to change to the new format?

Challenges & Solutions

- ❏ Time and energy to develop ConcepTest
  - ➢ **Database of ConcepTests (Project Galileo)**
    - ○ Astronomy ConcepTests
    - ○ Physics, Math, Geology, Life Sciences
    - ○ Chemistry
- ❏ We can be the contributor to the Project Galileo database!

Challenges & Solutions

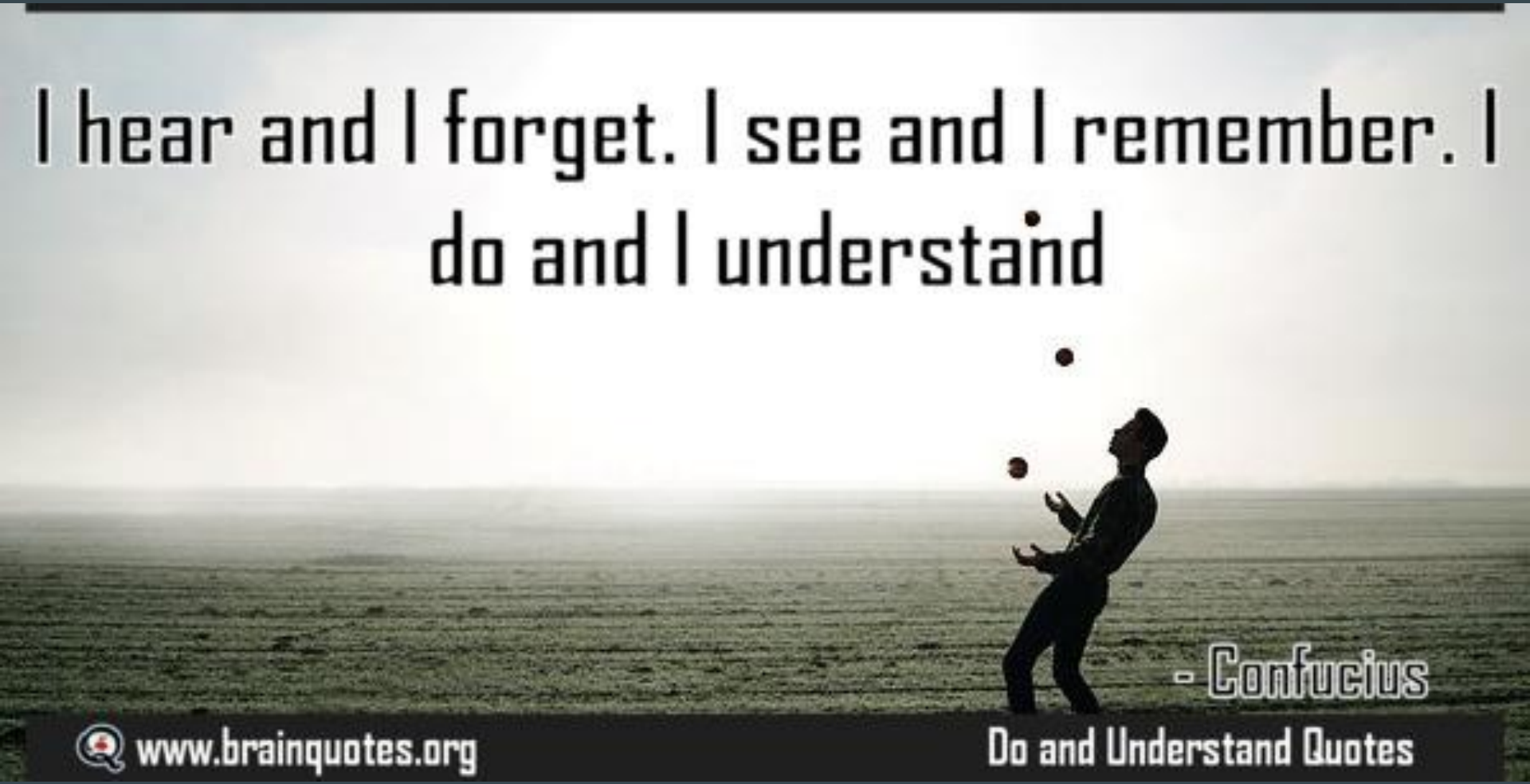
- ❏ Colleagues are skeptical
  - ➢ Show them the numbers
  - ➢ Invite them to your class!
- ❏ Coverage of course
  - ➢ Reduce the course
  - ➢ Students assignments

Challenges & Solutions

- ❏ Students resistance
  - ➢ Explain them well the idea behind at the start
  - ➢ Show them class data on a regular basis
- ❏ Fully engaging students

"Some students were too cool, too alienated, or perhaps too lost to participate!"

  - ➢ Circulate, passively participate, encourage
  - ➢ Incentivize participation


I hear and I forget. I see and I remember. I do and I understand
- Confucius
www.brainquotes.org
Do and Understand Quotes

References

[1]For example, see I. Halloun and D. Hestenes, ''The initial knowledge state of college physics students,'' Am. J. Phys. **53** (11), 1043–1055 (1985); L. C. McDermott, ''Millikan Lecture 1990: What we teach and what is learned—Closing the gap,'' *ibid.* **59**, 301–315 (1991); R. R. Hake, ''Interactive-engagement vs. traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses,'' *ibid.* **66** (1), 64–74 (1998).

[4]Eric Mazur, *Peer Instruction: A User's Manual* (Prentice–Hall, Upper Saddle River, NJ, 1997). Additional information and resources for PI can be found at http://galileo.harvard.edu.

[7]Gregor Novak, Evelyn Patterson, Andrew Gavrin, and Wolfgang Christian, *Just-in-Time Teaching: Blending Active Learning and Web Technology* (Prentice–Hall, Upper Saddle River, NJ, 1999), and http://webphysics.iupui.edu/jitt/jitt.html.

Thank you!