

Students as co-creators: Strategies for high quality engagement and learning

Judy Hardy and Alison Kay
School of Physics & Astronomy
University of Edinburgh

j.hardy@ed.ac.uk a.e.kay@sms.ed.ac.uk

- Students as co-creators of learning
- Active engagement: examples
 - Peer instruction
 - Flipped classroom
 - PeerWise
- Barriers to adoption
 - Why research evidence is not always enough

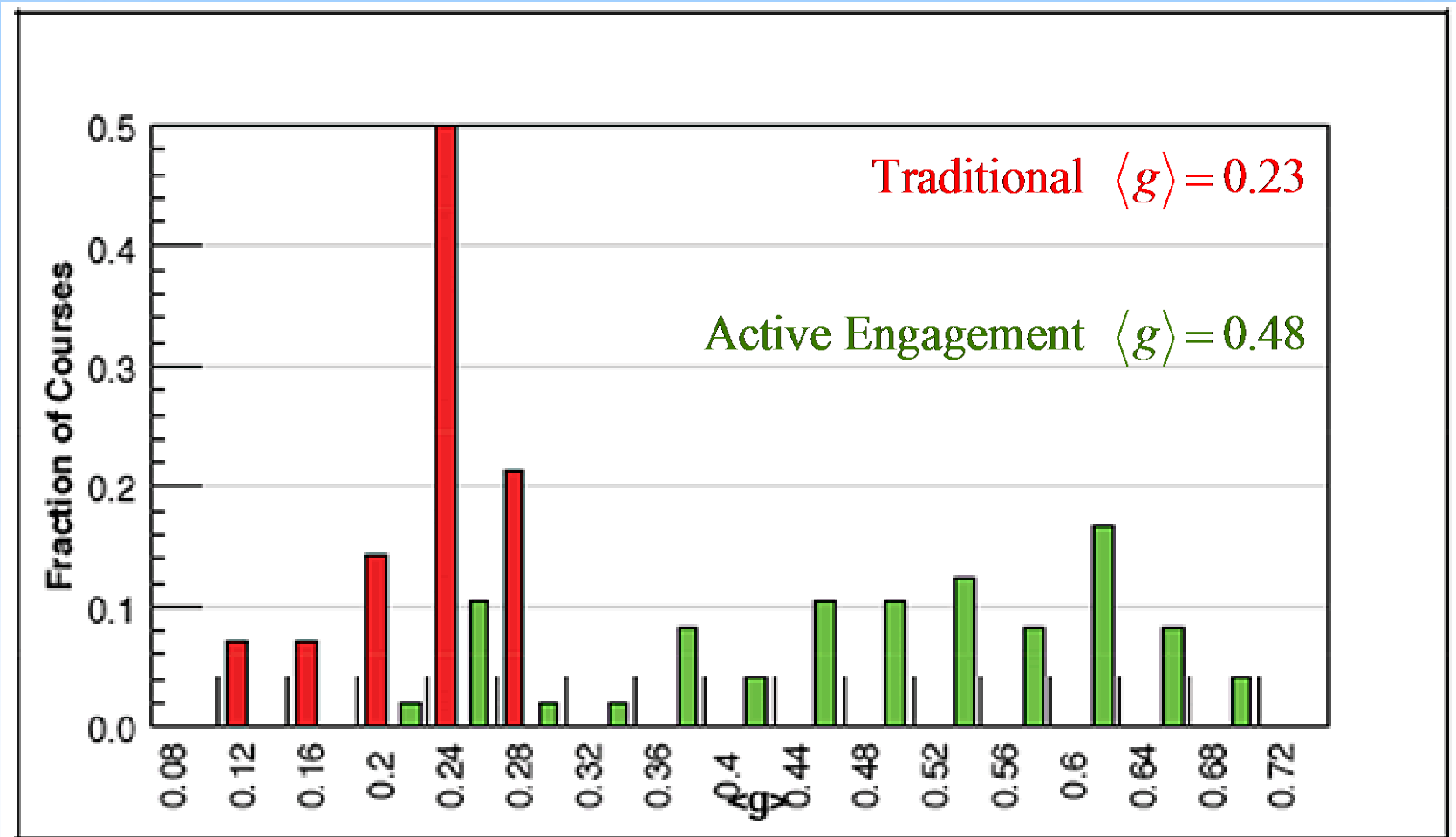
Students as co-creators of learning?



- Interactive engagement
 - ‘Promote conceptual understanding through...heads-on (always) and hands-on (usually) activities which yield immediate feedback through discussion with peers and/or instructors’

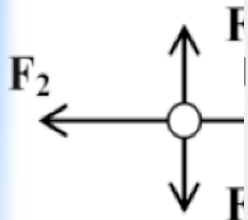
R.R. Hake, Am. J. Phys. **66**, 64 (1998)





Question title: Four forces

Four forces, F_1 , F_2 , F_3 and F_4 . The arrows in the accompanying figure represent the directions of the four forces but not their magnitudes. Which of the following relationships represents best how the magnitudes of the four forces are related?



- a. $F_4 = F_2$ and $F_3 = F_1$
- b. $F_4 = F_2$ and $F_3 > F_1$
- c. $F_4 > F_2$ and $F_3 > F_1$
- d. $F_4 > F_2$ and $F_3 = F_1$
- e. $F_4 > F_2$ and $F_3 < F_1$

Response Summary

Answer	Value
a.	100.00%
b.	0.00%
c.	0.00%
d.	0.00%
e.	0.00%

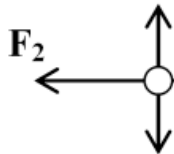
F2: Detail Summary

Question Statistics

Assessment title: Diagnostic test 1

Question title: Four forces

Four forces, F_1 , F_2 , F_3 and F_4 are exerted together on a hockey puck. The puck moves at constant speed along a straight line in the direction of F_4 . The arrows in the accompanying figure represent the directions of the four forces but not their magnitudes. Which of the following relationships represents best how the magnitudes of the four forces are related?



- a. $F_4 = F_2$ and $F_3 = F_1$
- b. $F_4 = F_2$ and $F_3 > F_1$
- c. $F_4 > F_2$ and $F_3 > F_1$
- d. $F_4 > F_2$ and $F_3 = F_1$
- e. $F_4 > F_2$ and $F_3 < F_1$

Response Summary

Answer	Value
a.	100.00%
b.	0.00%
c.	0.00%
d.	0.00%
e.	0.00%

Grade Distribution

Grade	Frequency
0-10	187
11-20	0

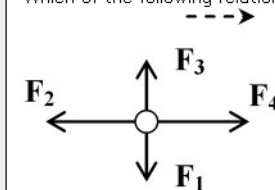
Four forces F1 F2: Detail Summary

Summary

Question Statistics

Assessment title: Diagnostic test 1
Question title: Four forces F1 F2

Four forces, F_1 , F_2 , F_3 and F_4 are exerted together on a hockey puck. The puck moves at constant speed along a straight line in the direction of F_4 . The arrows in the accompanying figure represent the directions of the four forces but not their magnitudes. Which of the following relationships represents best how the magnitudes of the four forces are related?



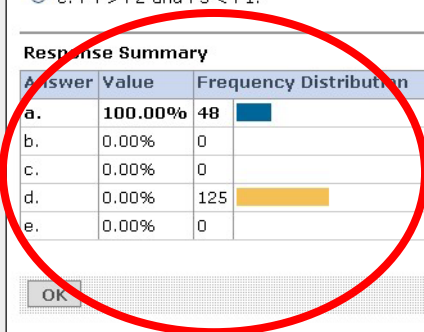
- a. $F_4 = F_2$ and $F_3 = F_1$
- b. $F_4 = F_2$ and $F_3 > F_1$
- c. $F_4 > F_2$ and $F_3 > F_1$
- d. $F_4 > F_2$ and $F_3 = F_1$
- e. $F_4 > F_2$ and $F_3 < F_1$

Response Summary

Answer	Value	Frequency Distribution
a.	100.00%	48
b.	0.00%	0
c.	0.00%	0
d.	0.00%	125
e.	0.00%	0

OK

the direction



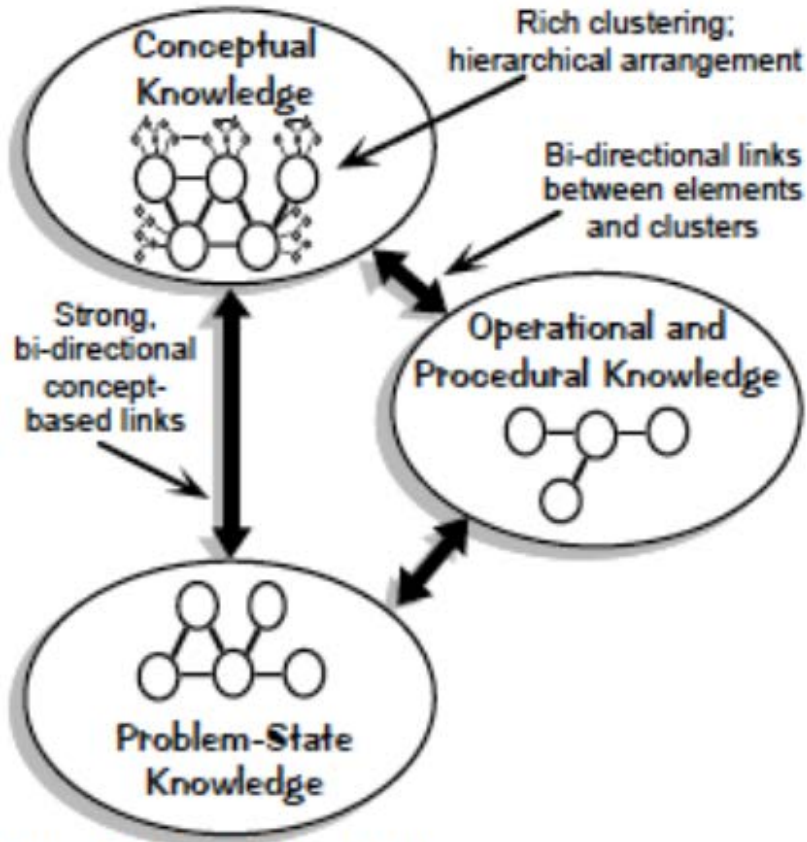


Fig. 1: Expert's knowledge store.

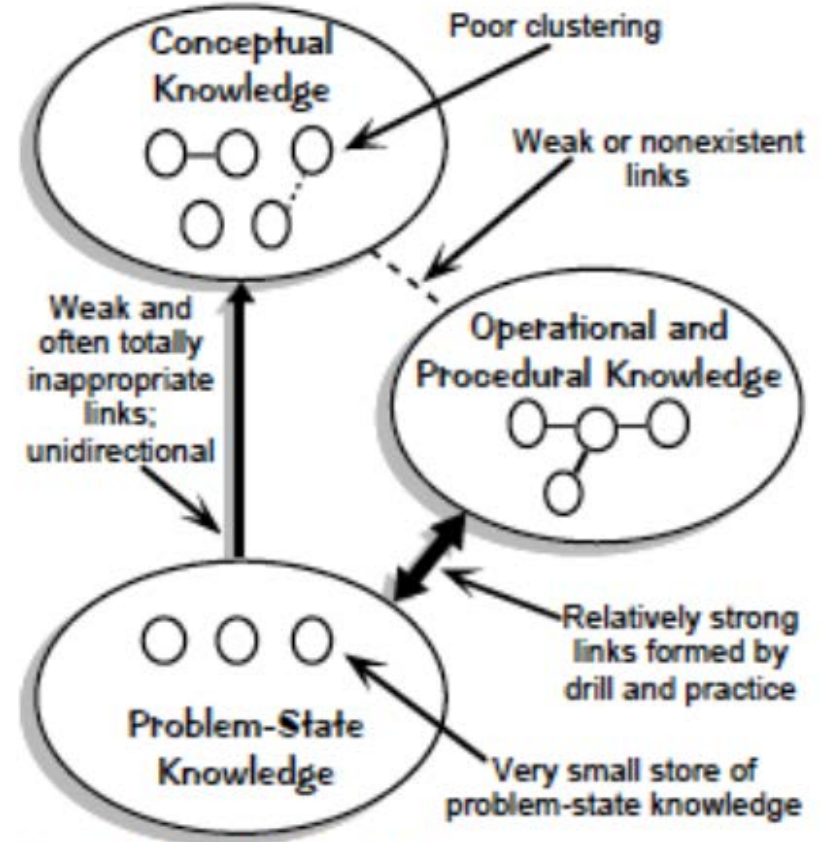
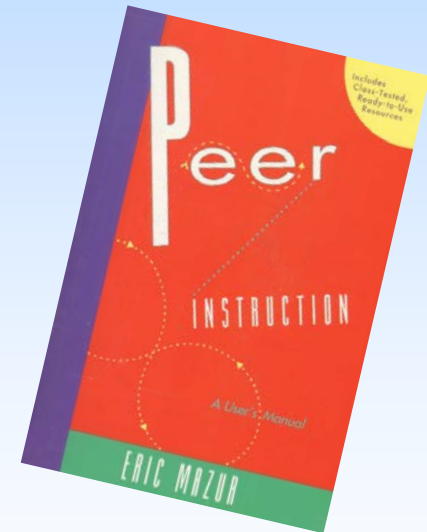


Fig. 2: Novice's knowledge store.

W.J. Gerace, in *Phys. Educ. Res. Conf. 2001* (Rochester, New York, 2001)

- Some examples from our own teaching & research:
- Peer instruction
- Flipped classroom
- PeerWise



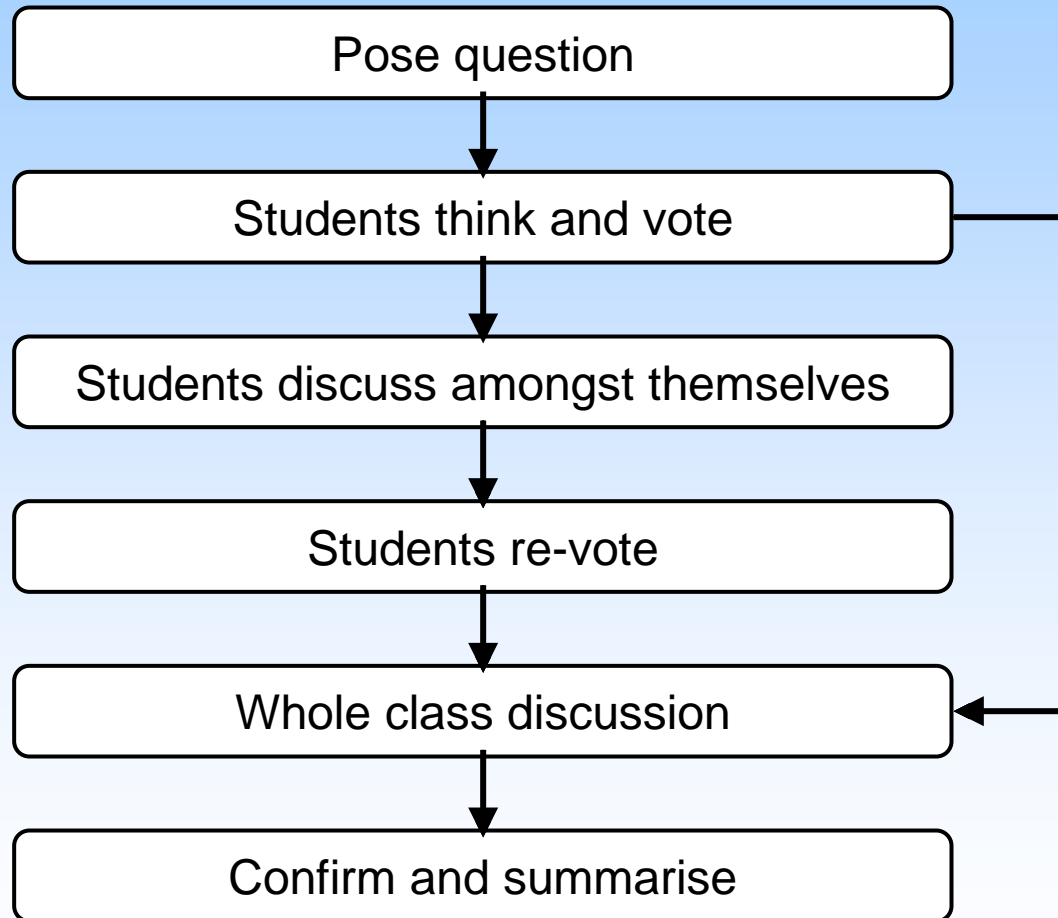
Peer Instruction

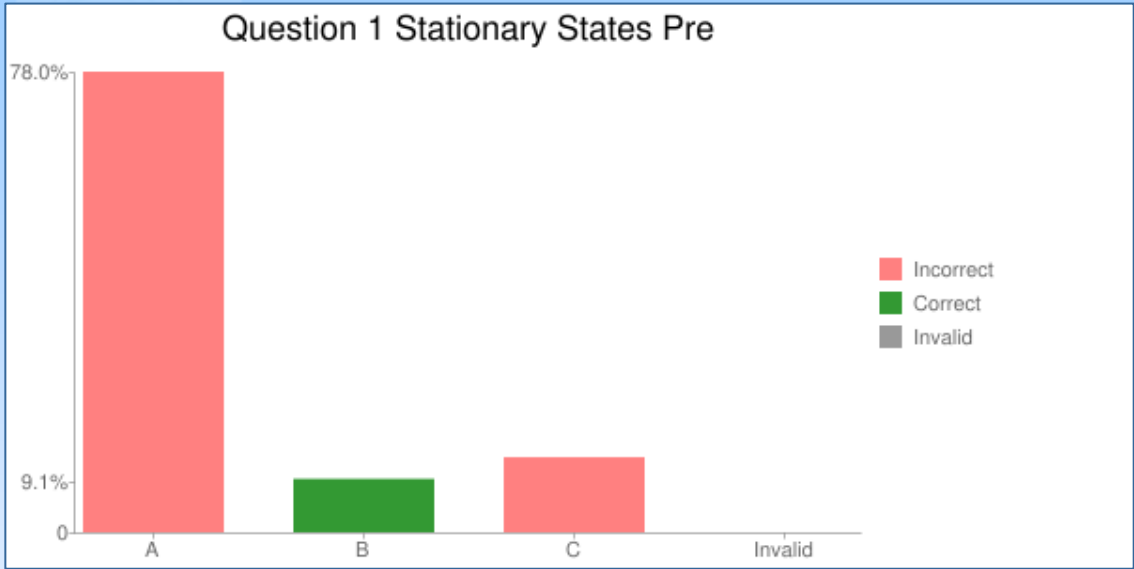


- Ausubel's Dictum: *'Ascertain what the student knows and teach accordingly.'*
- Kathleen Fisher: *'Ascertain what the student misunderstands and teach accordingly.'*

D.P. Ausubel, J.D. Novak, H. Hanesian et al, (1968)

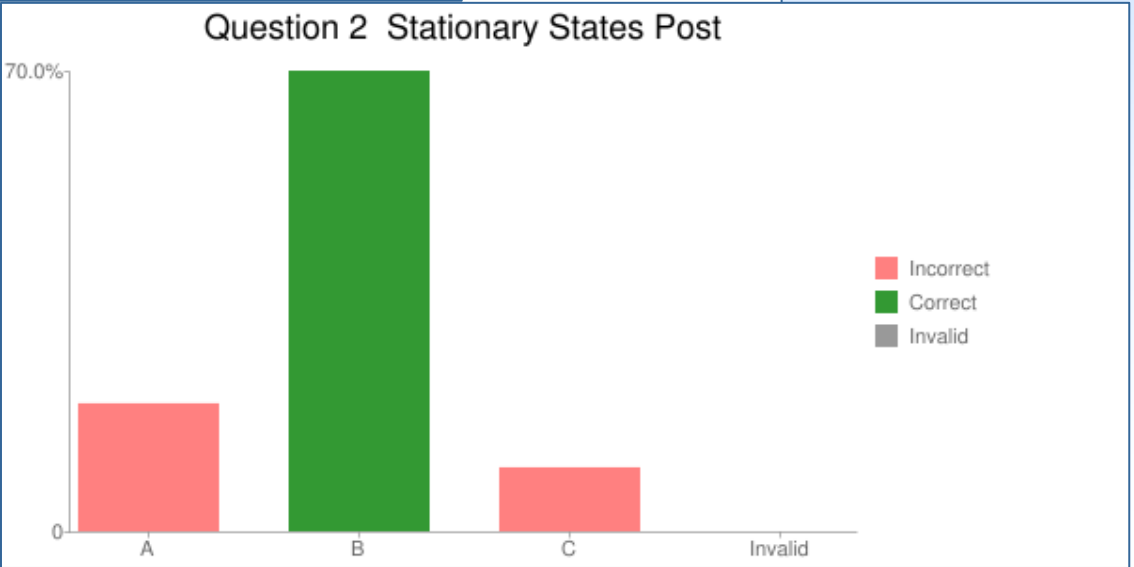
K.M. Fisher and D.E. Moody, in *Mapp. Biol. Knowl.* (Springer, 2002), pp. 55–75

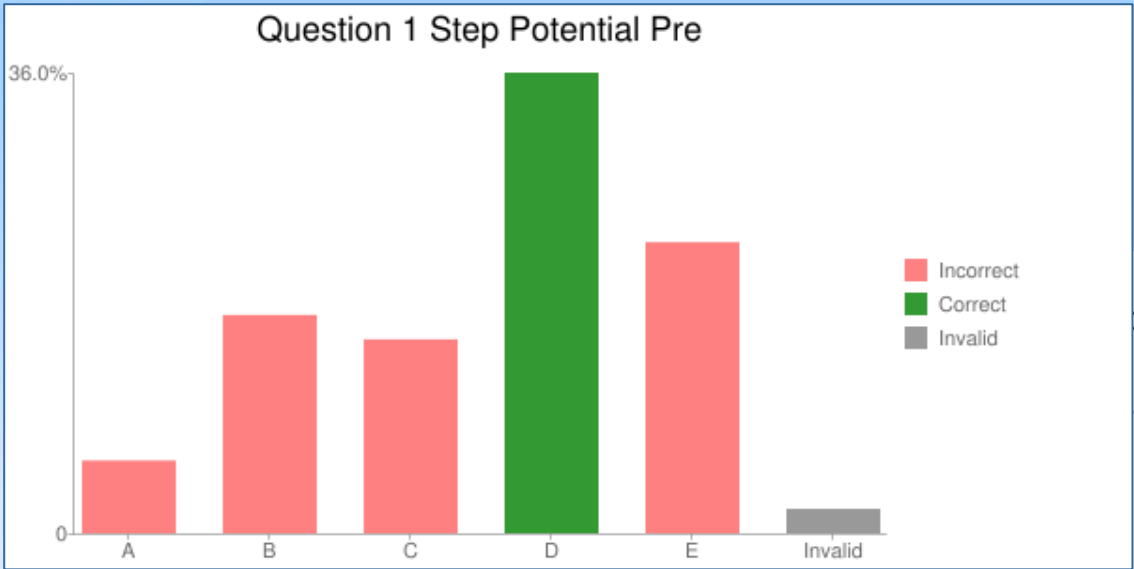




Stationary states (energy eigenstates) have **different** energy values ($E_1 \neq E_2$)
 Stationary state?

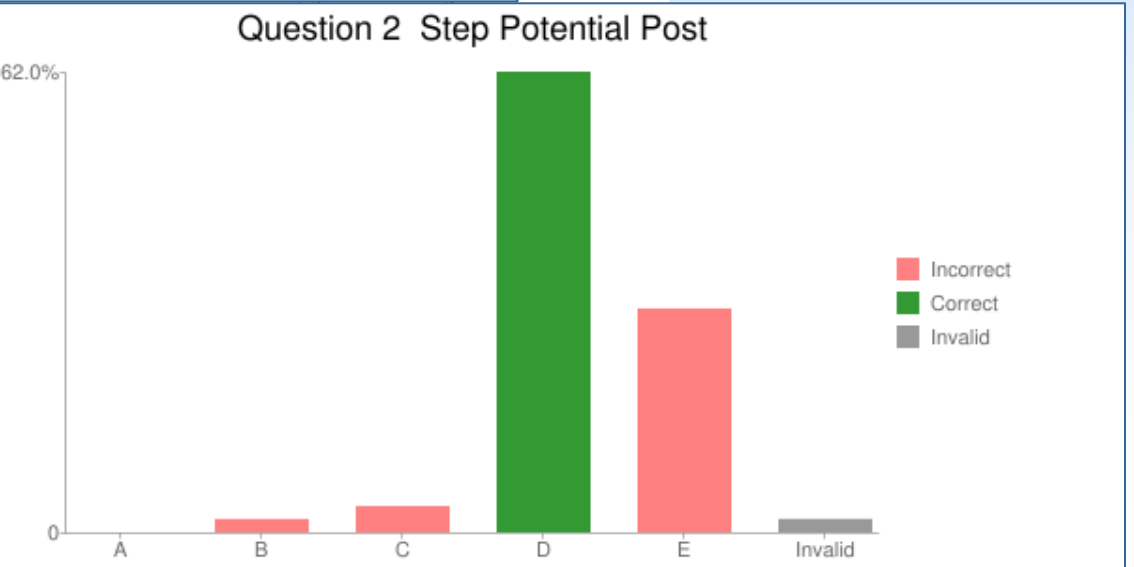
- A. Yes, always
- B. No, never
- C. Possibly yes



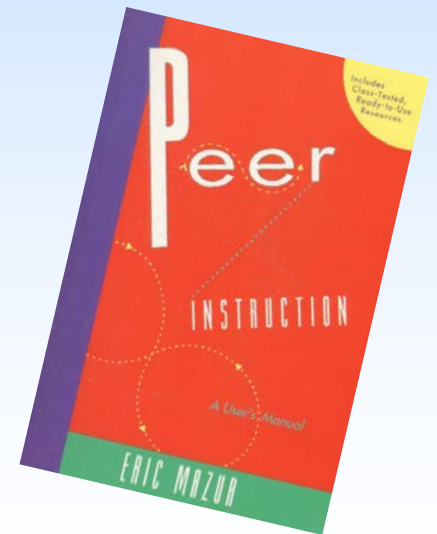


. The

$\psi(x)$ for
 $\psi(x)$ for
 To represent the p
 coefficient (A-D) n
 more than one, sh



Flipped classroom



Week
 $n-1$

Pre-lecture study

Course resources

Pre-lecture quiz

'What I still don't understand...'

Week
 n

Lectures

Peer instruction

Workshop

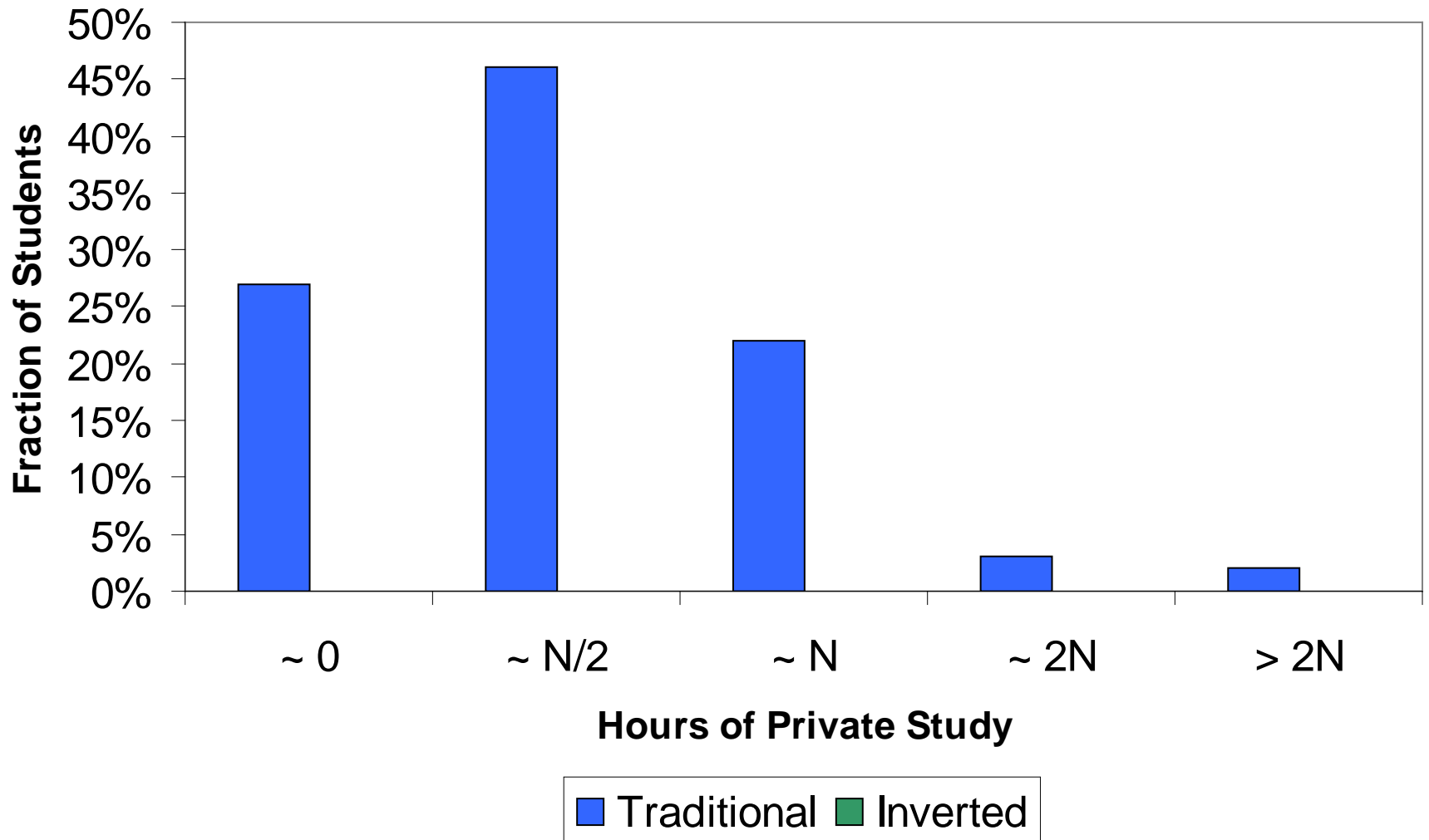
Problem solving

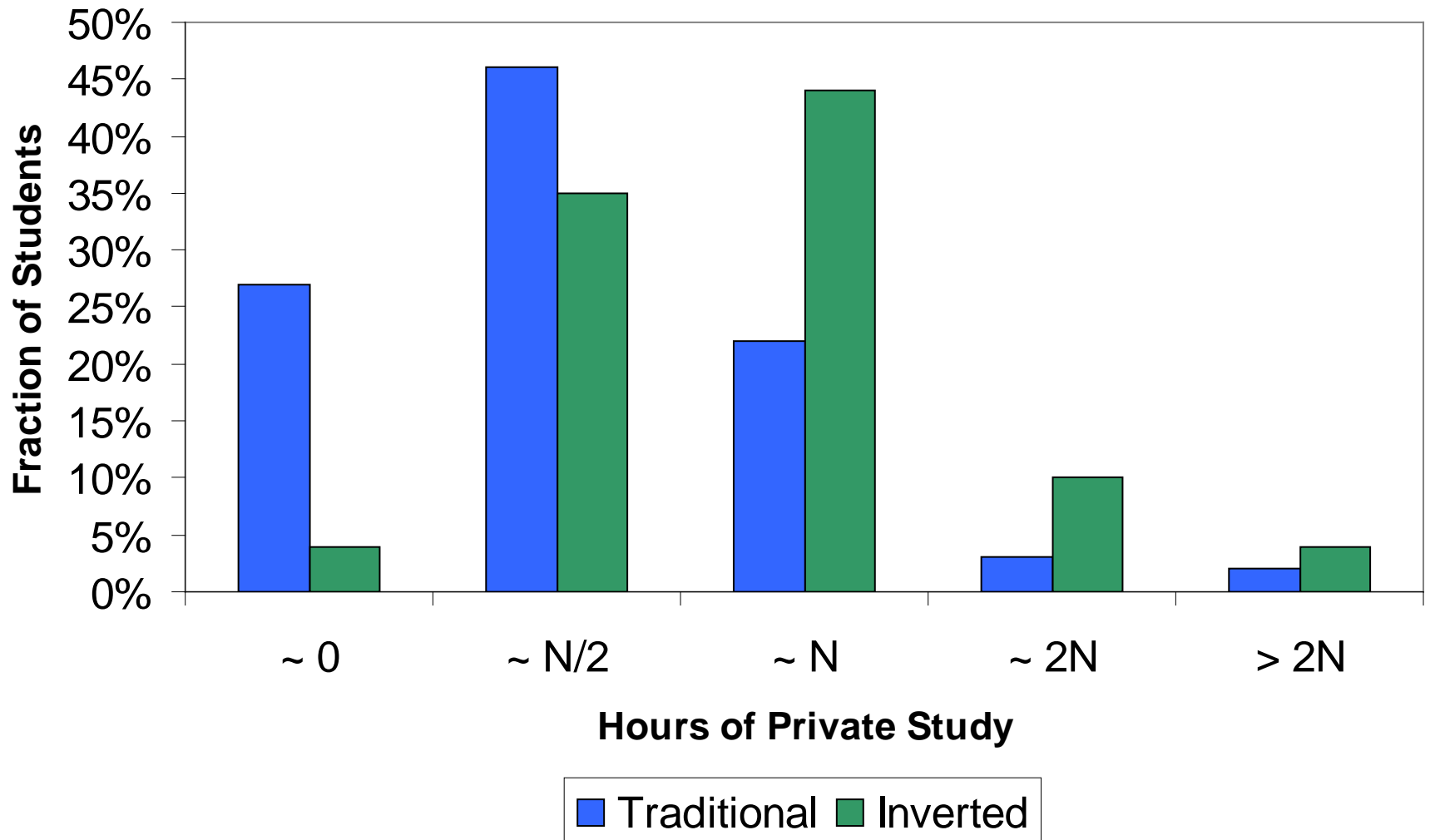
Week
 $n+1$

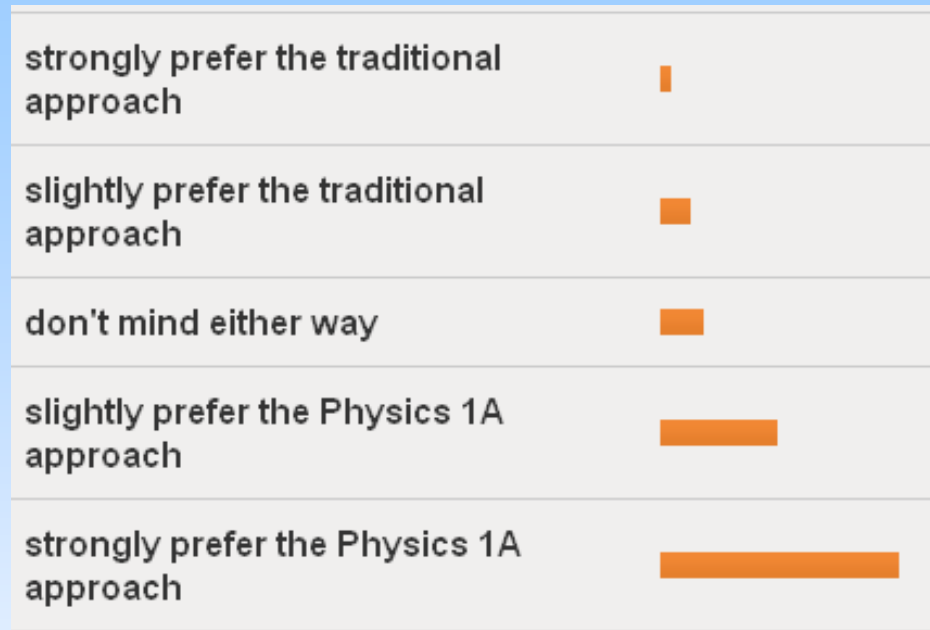
Hand-in assignment

Problems

PeerWise



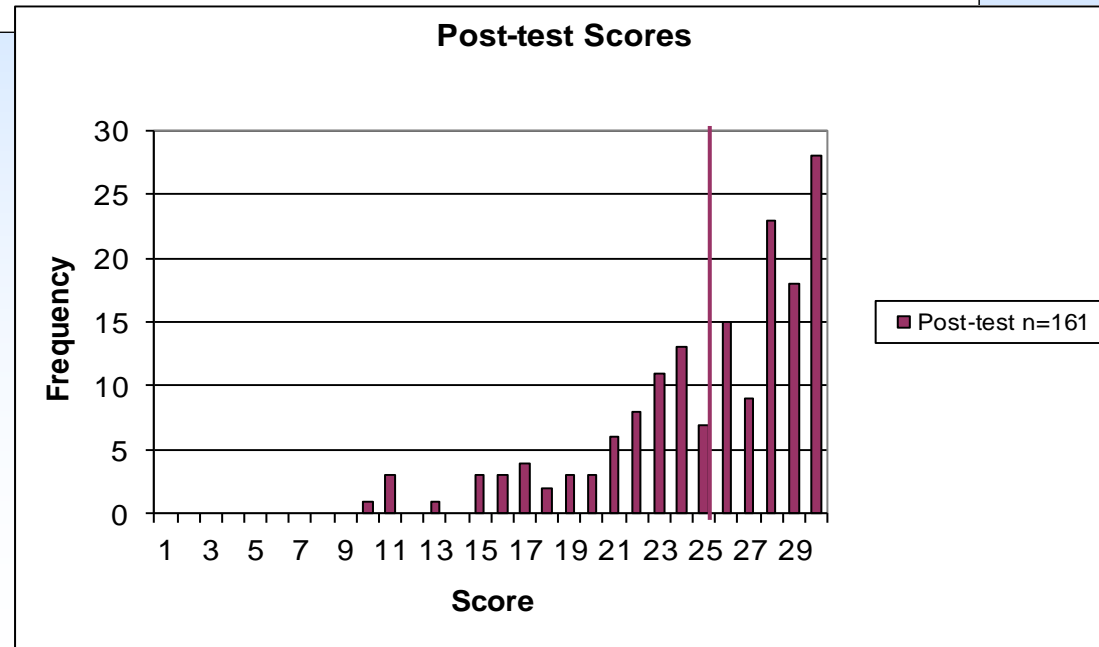
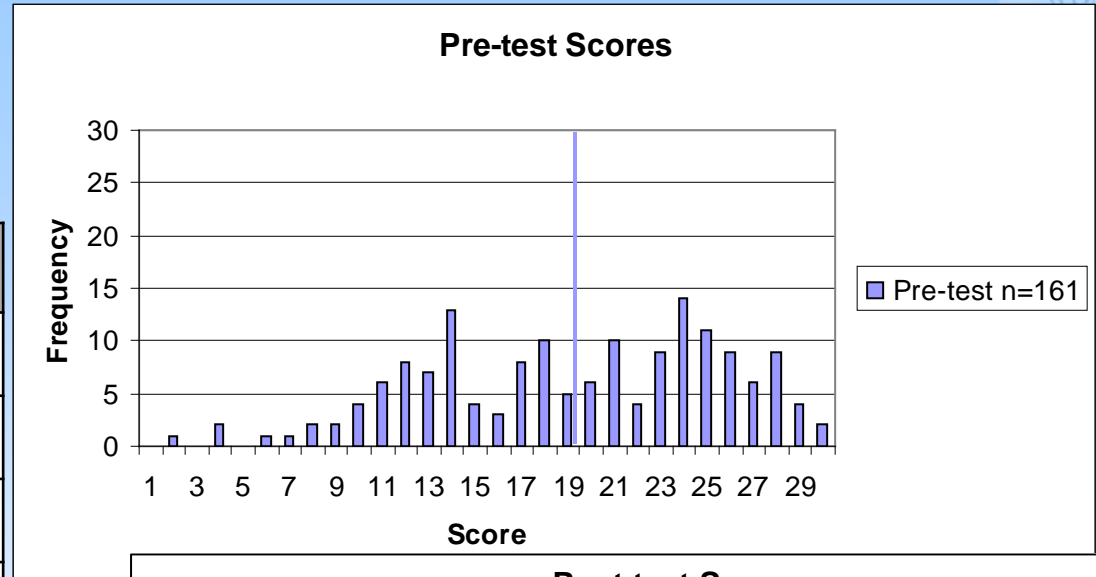


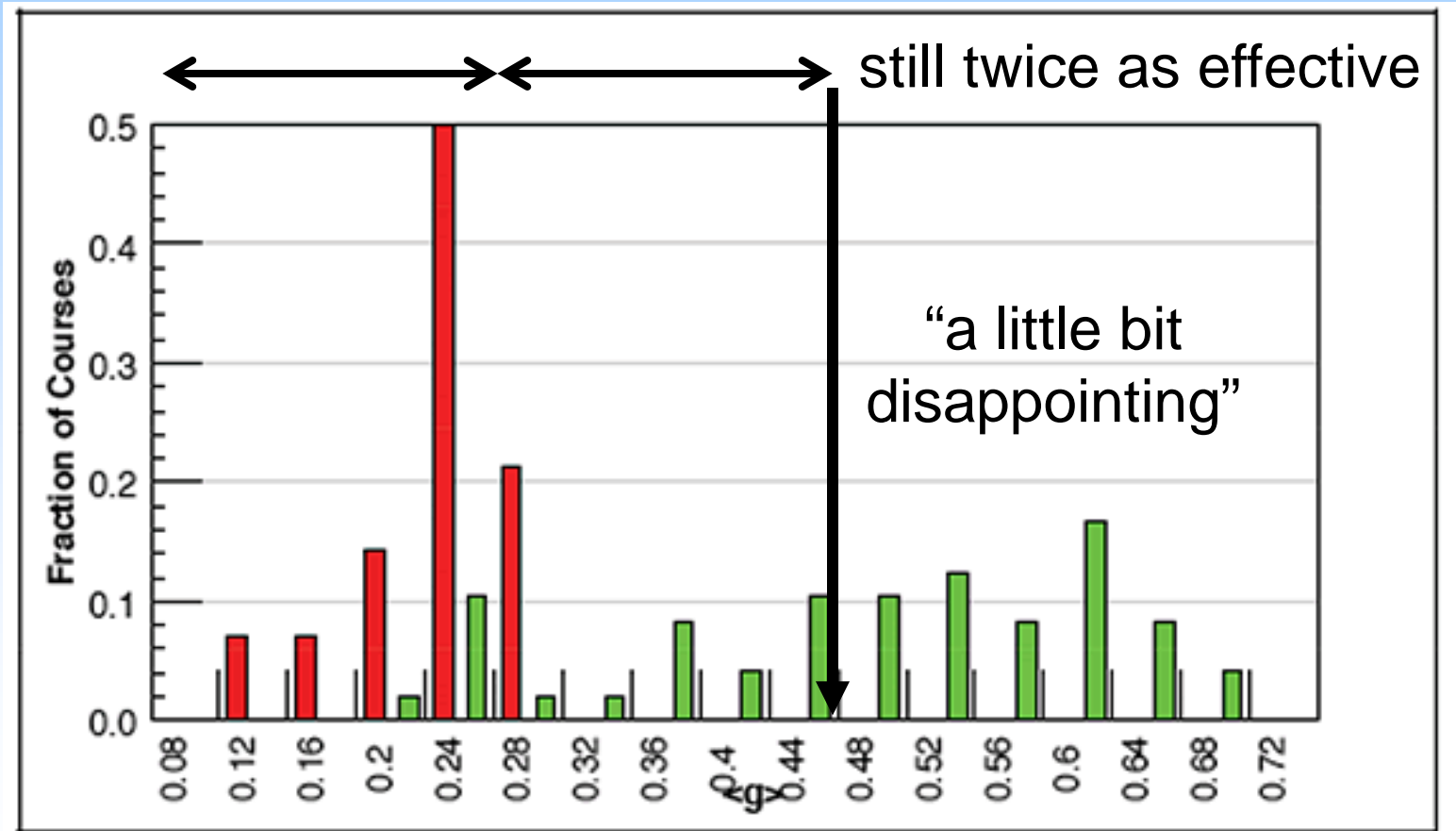


- Really like that you need to prepare for the lectures as the lectures themselves are much more interesting.
- This was more interactive, which helped further our understanding of the material. I strongly believe you learn from doing rather than listening.
- Sometimes it would have been more useful to explore formulas, derive things and especially explain everything.
- Too much clicker questions at lecture and not enough explanation.

Does it work?

Year	$\langle g \rangle$
2006-07	0.33(4)
2007-08	0.58(2)
2008-09	0.54(2)
2009-10	0.54(2)
2010-11	0.38(3)
2011-12	0.55(3)
2012-13	0.44(3)
2013-14	0.45



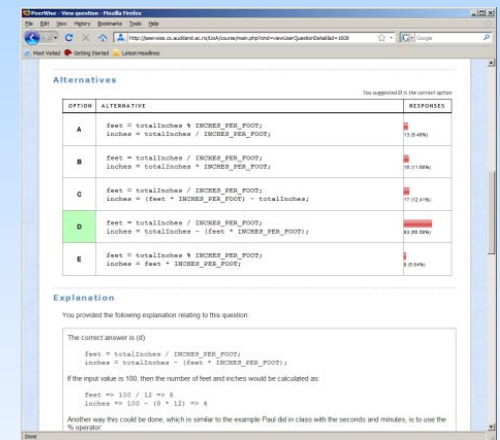


PeerWise



<https://peerwise.cs.auckland.ac.nz>

- Web-based MCQ repository
- Content created by and for students
 - Write questions & associated explanations
 - Answer questions written by other students
 - Rate questions for quality & difficulty
 - Take part in discussions
 - Follow other authors



Alternatives

OPTION	ALTERNATIVE	RESPONSE
A	feet = totalInches * INCHES_PER_FOOT; inches = totalInches / INCHES_PER_FOOT;	19.8 (4%)
B	feet = totalInches / INCHES_PER_FOOT; inches = totalInches * INCHES_PER_FOOT;	18.0 (4%)
C	feet = totalInches / INCHES_PER_FOOT; inches = (feet * INCHES_PER_FOOT) - totalInches;	17.0 (4%)
D	feet = totalInches / INCHES_PER_FOOT; inches = totalInches - (feet * INCHES_PER_FOOT);	33.8 (8%)
E	feet = totalInches * INCHES_PER_FOOT; inches = feet * INCHES_PER_FOOT;	9.8 (4%)

Explanation

You provided the following explanation relating to this question:

The correct answer is (D)

$$\text{feet} = \text{totalInches} / \text{INCHES_PER_FOOT};$$

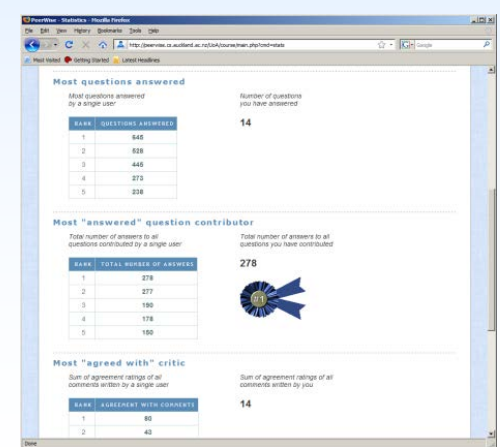
$$\text{inches} = \text{totalInches} - (\text{feet} * \text{INCHES_PER_FOOT});$$

If the input value is 100, then the number of feet and inches would be calculated as:

$$\text{feet} \Rightarrow 100 / 12 \Rightarrow 8$$

$$\text{inches} \Rightarrow 100 - (8 * 12) \Rightarrow 4$$

Another way this could be done, which is similar to the example Paul did in class with the seconds and minutes, is to use the % operator.



Most questions answered

RANK	QUESTIONS ANSWERED	Number of questions you have answered
1	645	14
2	628	
3	446	
4	275	
5	228	

Most "answered" question contributor

RANK	TOTAL NUMBER OF ANSWERS	Total number of answers to all questions you have contributed
1	278	278
2	277	
3	199	
4	174	
5	150	

Most "agreed with" critic

RANK	AGREED WITH COMMENTS	Sum of agreement ratings of all comments written by a single user
1	83	14
2	43	

- Introduced in hands-on workshop session
- Students worked through structured examples then devised own Qs in groups
- Encouraged to choose topics in their 'Zone of Proximal Development'




L.S. Vygotsky, *Mind in Society: The Development of Higher Psychological Processes* (Harvard University Press, Cambridge, MA, 1978).

Typical assessment requirements: Physics 1A

- Two deadlines
 - Spaced through the semester
- Minimum requirements per deadline:
 - Write 1 question
 - Answer 5
 - Comment on & rate 3
- Contributes 4% to course assessment



Comments

There are **17** comments for this question (17 top-level comments and 0 replies) 

Written: 9:19pm, 20 Nov Author has: [2317](#) points and [13](#) badges



Nice question! A more interesting conservation of momentum question, and Richie Gray was involved so that always a bonus! *(by: [redacted])*



[Reply to this comment](#)

Written: 9:34pm, 20 Nov

Author has: [2030](#) points and [20](#) badges



Good question, still doesn't help Scotland score any points though ;) *(by: [redacted])*



[Reply to this comment](#)

Written: 9:40pm, 20 Nov

Author has: [721](#) points and [8](#) badges



Good context, creates an exam-like feel. Thanks for reminding us that there's a negative! *(by: [redacted])*



[Reply to this comment](#)

Written: 9:24pm, 20 Nov

Author has: [949](#) points and [7](#) badges

very good question, nice sporting incident aswell *(by: [redacted])*



[Reply to this comment](#)

Written: 9:29pm, 20 Nov

Author has: [1385](#) points and [11](#) badges

Definitely can't fault this, with the physics or the image of it happening. Nice and simple, but with the possible hiccup of the negative there. *(by: [redacted])*



[Reply to this comment](#)

Written: 9:47pm, 20 Nov

Author has: [453](#) points and [7](#) badges

Really liked the set up of the question, although could have added unnecessary data as distracters. *(by: [redacted])*



[Reply to this comment](#)

Written: 10:05pm, 20 Nov

Author has: [1721](#) points and [10](#) badges

You could have had the same answers with different signs to confuse people, but good question testing conservation of momentum! *(by: [redacted])*



[Reply to this comment](#)

Written: 10:15pm, 20 Nov

Author has: [771](#) points and [9](#) badges

Nice question. *(by: [redacted])*



Question writing, creating distractors and explaining answers – synthesizing materials, meta-cognitive awareness

Creation of a bank of questions to test knowledge and understanding

Reviewing questions and explanations – critical thinking, evaluation

Courses in this study

Physics 1A (Edinburgh) 1st year 1st semester

Physics 1B (Edinburgh) 1st year 2nd semester follow on from 1A

Physics 2 (Glasgow) 2nd year full year course

Multiple Measure of PeerWise engagement

Number of questions authored

Number of questions answered

Number of *quality* comments given

Number of *quality* comments received

Standardized and summed for each student

Is overall engagement associated with higher exam performance?

Do any associations remain when controlling for prior-ability?

Dependent Variable:

Independent Variable(s):

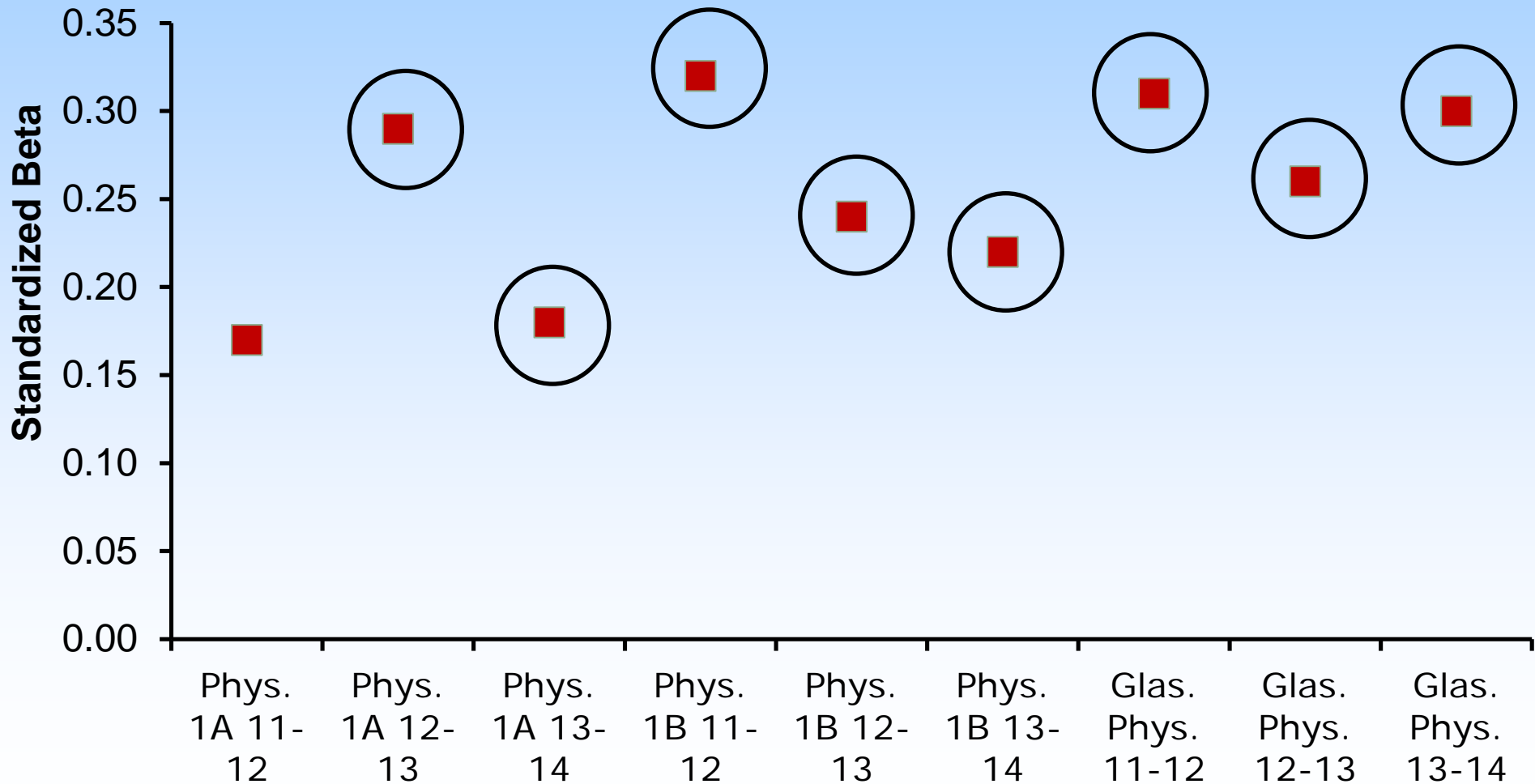
Exam score

MM

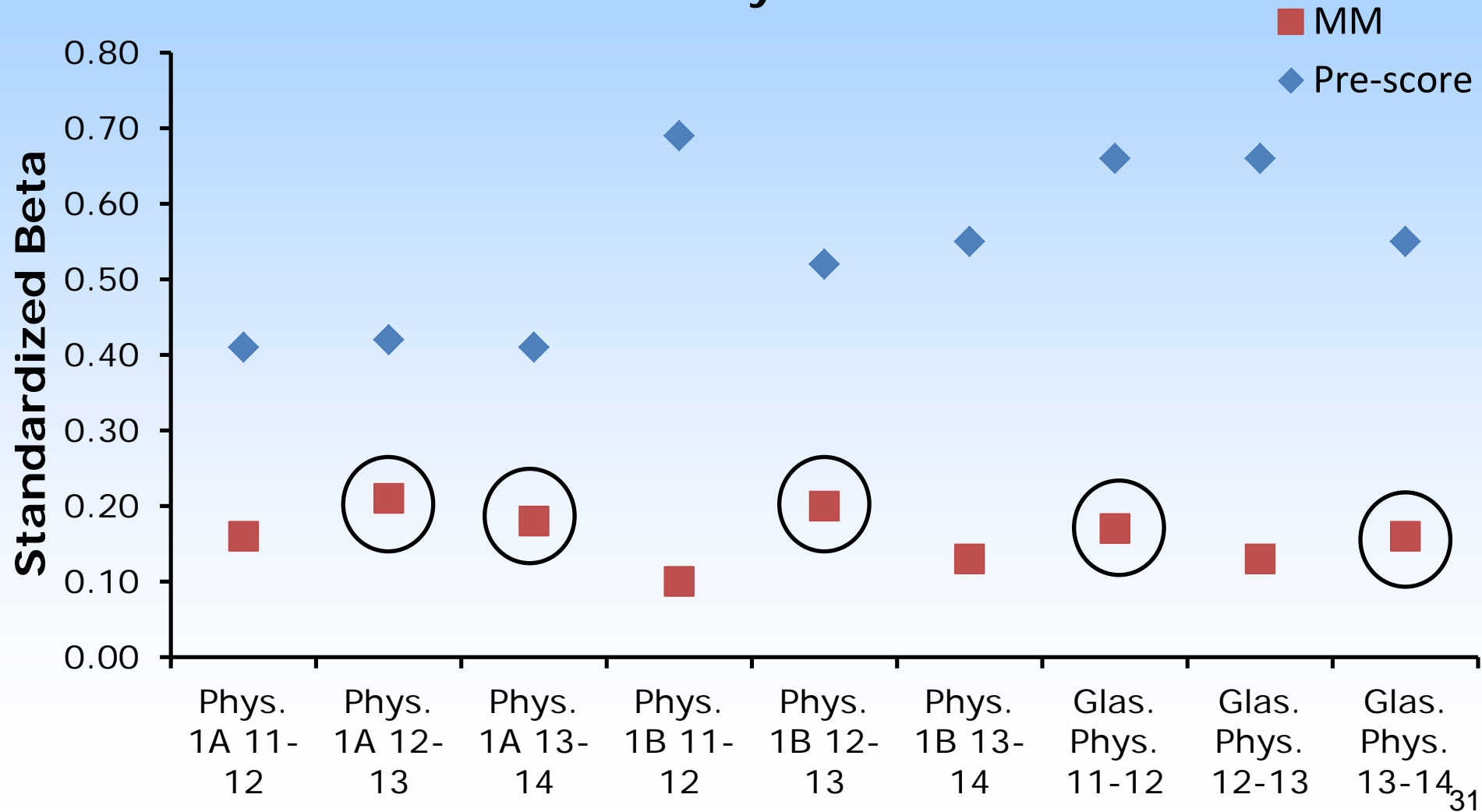
Pre-score

before PeerWise use

Plot of standardized coefficients from regression analysis



Plot of standardized coefficients from regression analysis



Complicated relationship between PeerWise engagement and attainment

Small but significant effects: PeerWise is a small component of course; exams no MCQ component

Are effects consistent across ability levels and courses?

More philosophical question: is exam performance the best way to capture skills PeerWise aims to promote?

Barriers to adoption

- **Barriers to adoption:**
 - Why is research evidence not always enough?

“Good ideas, supported by convincing evidence of efficacy, will spread ‘naturally’—that, on learning about the success of particular initiatives, others will become convinced enough to try them.

The evidence in support of this theory is...lacking”

E. Seymour, *Sci. Educ.* **86**, 79 (2002)

- Survey of 281 academic staff in 37 UK university physics departments:

Agree /
strongly agree

Disagree /
strongly disagree

12%

If I **didn't have to** teach, I wouldn't

77%

26%

Teaching is the **most useful thing** I do as an academic

33%

84%

I take as much **professional pride** in my teaching
as I do in my research

9%

Teaching staff are dedicated and engaged

Are staff aware of teaching innovations?

- USA study (722 physics faculty):
 - 87% of respondents familiar with at least one evidence-based reformed instructional strategy
 - 27% use at least one of them

M. Dancy and C. Henderson, *Am. J. Phys.* **78**, 1056 (2010)

- UK study (281 physics faculty):
 - 64% of respondents familiar with at least one evidence-based reformed instructional strategy
 - 48% use at least one of them

J. Hardy et al., *Fostering Learning Improvements in Physics* (2014)

What are the challenges for staff?

Structural factors

- USA study:
 - 53% of respondents said lack of time prevented them from using research-informed instructional strategies
- UK study:
 - 44% of respondents said they do not have enough time to teach the way they would like to

Preparation [for flipped classroom] took roughly 20 hours for the first class, dropping to 10 hours by the third class. We estimate that under normal circumstances a moderately experienced instructor would require about 5 hours of preparation time per one hour class.

What are the challenges for staff? Pedagogical context

I tried to use clickers, but I didn't see any improvements, so I returned to traditional lecturing.

There are too many choices of teaching innovations; I don't know which to choose.

J.M. Fraser et al., Rep. Prog. Phys. **77**, 032401 (2014)

- USA study:
 - ~1/3 of respondents who tried a research-informed instructional strategy subsequently stopped

C. Henderson et al., Phys. Rev. Spec. Top. - Phys. Educ. Res. **8**, 1 (2012)

- Only ~20-25% of staff use evidence-based teaching approaches without modification

C. Henderson and M. Dancy, Phys. Rev. Spec. Top. - Phys. Educ. Res. **5**, 020107 (2009)

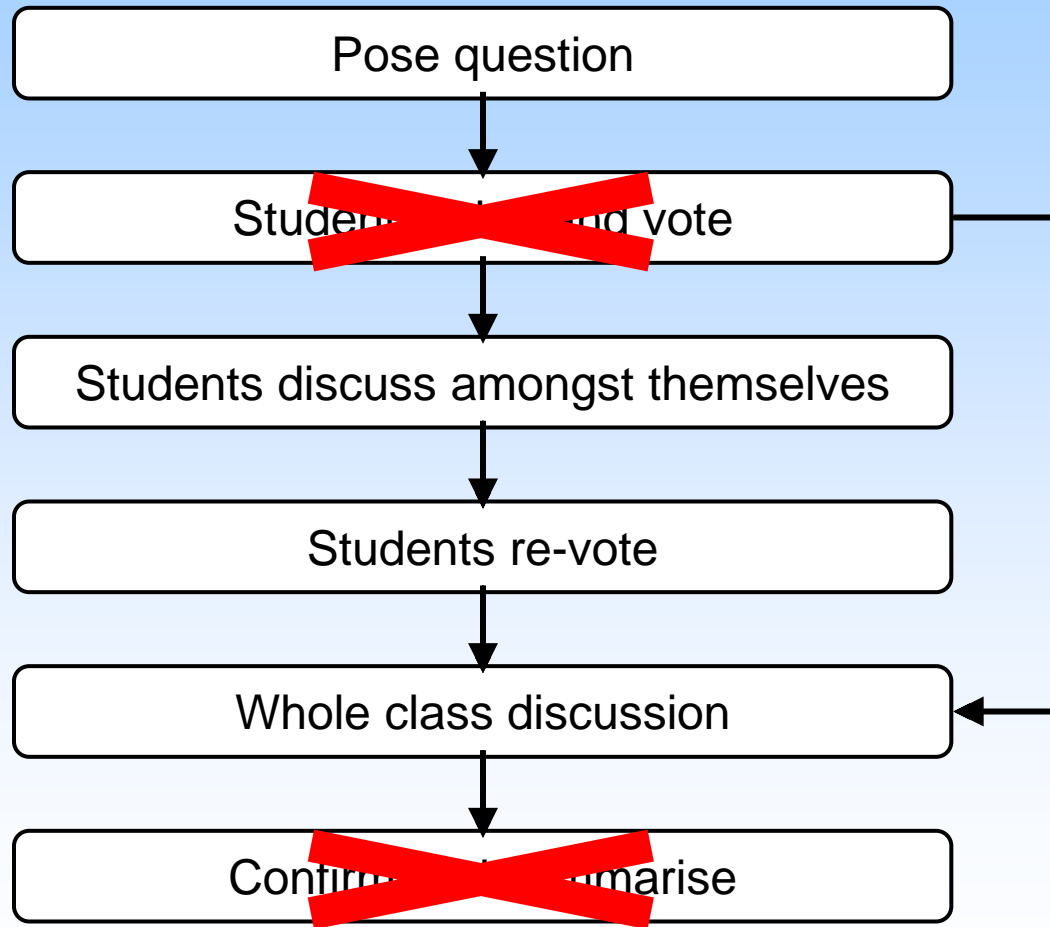
- Wide range of implementation practices leading to different classroom norms (during peer instruction)

C. Turpen and N.D. Finkelstein, Phys. Rev. Spec. Top. - Phys. Educ. Res. **6**, 020123 (2010)

- Extensive use of student test performance (by staff) and student evaluations (by institutions) to evaluate effectiveness (USA study)

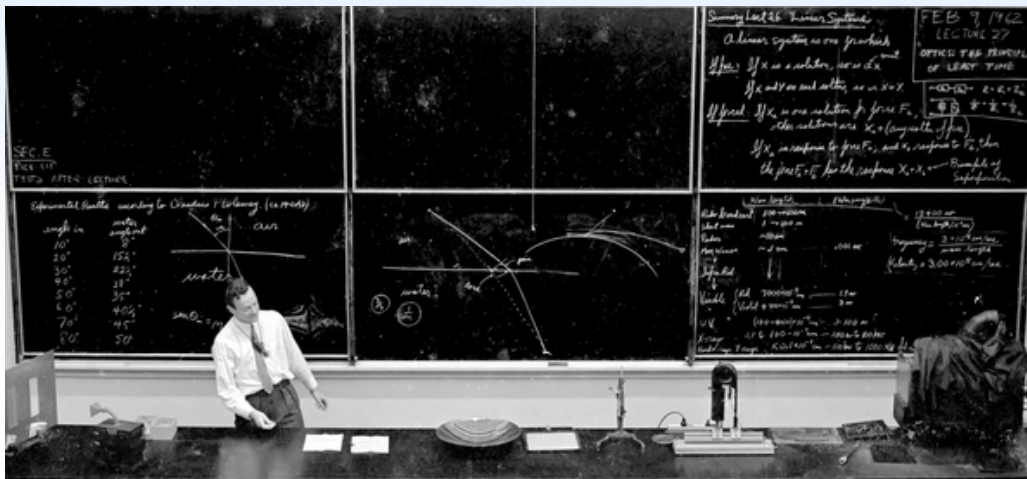
C. Henderson et al, Phys. Rev. Spec. Top. - Phys. Educ. Res. **10**, 010106 (2014)

Example: Peer Instruction



- ‘awareness’ knowledge
- ‘how-to’ knowledge
- ‘principles’ knowledge

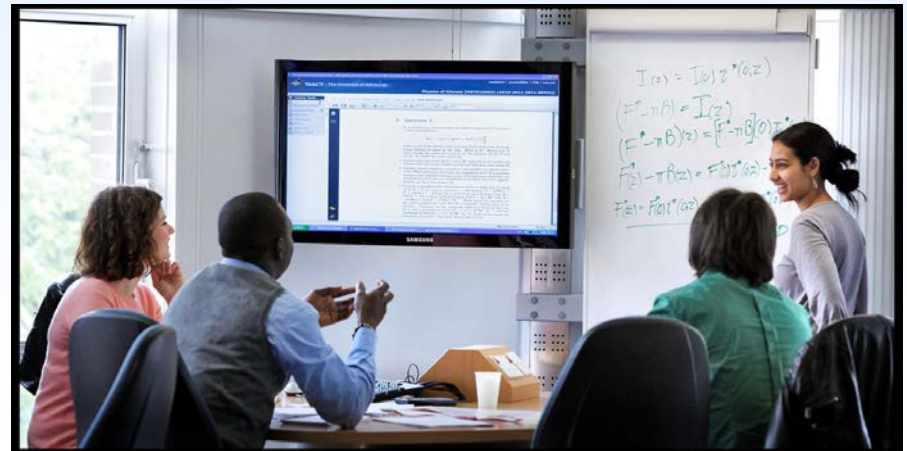
C. Henderson and M.H. Dancy, Am. J. Phys. **76**, 79 (2008)



So what can be done?

- Implementation in the classroom needs to be aligned with the underlying educational principles
- Educational reforms need to take account of the local, often complex, classroom context
- Effective strategies take time to embed

C. Henderson, A. Beach, and N. Finkelstein, *J. Res. Sci. Teach.* **48**, 952 (2011)



- Students as co-creators of learning
- Active engagement: examples
 - Peer instruction
 - Flipped classroom
 - PeerWise
- Barriers to adoption
 - Alignment between principles and practice
 - No quick fixes