

Physics Education Research The University of Edinburgh



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

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- 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)









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

#### EdPER Education Research Student difficulties & misconceptions





### EdPER Gerace's model of knowledge structure





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



### Active engagement



- 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, i*n Mapp. Biol. Knowl.* (Springer, 2002), pp. 55–75



#### **Peer** instruction





















#### Flipped classroom



E. Mazur, Peer Instruction: A User's Manual (Addison-Wesley, 1997)14



#### Flipped classroom























### Student views



strongly prefer the traditional approach	1
slightly prefer the traditional approach	-
don't mind either way	-
slightly prefer the Physics 1A approach	
strongly prefer the Physics 1A approach	

- 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?



		Pre-test Scores		
		30 25 ⋧ 20		
Year	<g></g>	<b>1</b> 5 ■ Pre-test n=161		
2006-07	0.33(4)			
2007-08	0.58(2)			
2008-09	0.54(2)	1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 Score		
2009-10	0.54(2)	Post-test Scores		
2010-11	0.38(3)	30		
2011-12	0.55(3)			
2012-13	0.44(3)		est n=161	
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**Education Research** 









#### PeerWise

#### **PeerWise** https://peerwise.cs.auckland.ac.nz



#### PeerWise



- 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

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 Introduced in hands-on workshop session

Education Researc

- 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).





Two deadlines

Education Researc

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



#### Comments

Nice question I A more interesting conservation of momentum question, and Richie Gray was involved so that always a bonus! (ay Replie this comment Replie this comment Replie this comment Good question, still doesn't help Scotland score any points though ;) (ay Replie the comment Inter: 9.40m; 20 Nov Author has: 2030 points and 20 badg Good question, still doesn't help Scotland score any points though ;) (ay Replie the comment Inter: 9.40m; 20 Nov Author has: 721 points and 8 badg Good context, creates an exam-like feel. Thanks for reminding us that there's a negative! (by: Replie this comment Inter: 9.24pm; 20 Nov Author has: 724 points and 7 badg Very good question, nice sporting incident aswell (by: Replie this comment Inter: 9.24pm; 20 Nov Author has: 1985 points and 7 badg Very good question, nice sporting incident aswell (by: Replie this comment Inter: 9.24pm; 20 Nov Author has: 1985 points and 7 badg Replie this comment Inter: 9.24pm; 20 Nov Author has: 1985 points and 7 badg Replie this comment Inter: 9.24pm; 20 Nov Author has: 1985 points and 7 badg Replie this comment Inter: 9.24pm; 20 Nov Author has: 1985 points and 7 badg Really liked the set up of the question, although could have added unnecessary data as distracters. (by: Replie this comment Inter: 9.47pm; 20 Nov Author has: 1925 points and 7 badg Really liked the set up of the question, although could have added unnecessary data as distracters. (by: Replie this comment Inter: 10.5pm; 20 Nov Author has: 1721 points and 19 badg You could have had the same answers with different signs to confuse people, but good question resting conservation of momentum (by: Replie this comment Inter: 10.5pm; 20 Nov Author has: 771 points and 9 badg	ritten: 9:19pm, 20 Nov Author has:	2317 points and	13 badg
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#### 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





#### Physics 1A (Edinburgh) 1<sup>st</sup> year 1<sup>st</sup> semester

### Physics 1B (Edinburgh) 1<sup>st</sup> year 2<sup>nd</sup> semester follow on from 1A

Physics 2 (Glasgow) 2<sup>nd</sup> year full year course



PeerWise engagement and exam performance



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











## 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 / Disagree / strongly agree strongly disagree 12% 77% If I didn't have to teach, I wouldn't 26% 33% Teaching is the **most useful thing** I do as an academic I take as much **professional pride** in my teaching 84% **9%** as I do in my research Teaching staff are dedicated and engaged

J. Hardy et al., Fostering Learning Improvements in Physics (2014) 35





- 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)





#### • 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)







- 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