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?
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’

Interactive engagement


Traditional $\langle g \rangle = 0.23$

Active Engagement $\langle g \rangle = 0.48$
Four forces, F1, F2, F3 and F4 are exerted together on a hockey puck. The puck moves at constant speed along a straight line in the direction of F4. 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?
Gerace’s model of knowledge structure

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.’

Peer instruction

1. Pose question
2. Students think and vote
3. Students discuss amongst themselves
4. Students re-vote
5. Whole class discussion
6. Confirm and summarise
12

Question 1 Stationary States Pre

- Incorrect: 78.0%
- Correct: 9.1%
- Invalid: 0%

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

Question 2 Stationary States Post

- Incorrect: 0%
- Correct: 70.0%
- Invalid: 0%

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

- They have different energy levels (e.g., $E_1$, $E_2$)

- They are in the same stationary state?
Question 1 Step Potential Pre

ψ(x)(football)

ψ(x)(falling)

To represent the probability coefficient (A-D) more than one, show...
Flipped classroom

Flipped classroom

- **Week n-1**
  - Pre-lecture study
  - Course resources
  - Pre-lecture quiz
    - ‘What I still don’t understand…’

- **Week n**
  - Lectures
  - Peer instruction

- **Week n+1**
  - Workshop
    - Problem solving
  - Hand-in assignment
    - Problems
    - PeerWise
Time on task

![Bar graph showing the fraction of students by hours of private study.]

- ~0: 25% (Traditional)
- ~N/2: 45% (Traditional)
- ~N: 20% (Traditional)
- ~2N: ~5% (Traditional)
- >2N: ~5% (Traditional)

Legend:
- Blue: Traditional
- Green: Inverted

Hours of Private Study

Fraction of Students
Time on task

![Chart showing the fraction of students in different categories of hours of private study for Traditional and Inverted methods.](image-url)
Student views

<table>
<thead>
<tr>
<th>Preference</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>strongly prefer the traditional approach</td>
<td></td>
</tr>
<tr>
<td>slightly prefer the traditional approach</td>
<td></td>
</tr>
<tr>
<td>don't mind either way</td>
<td></td>
</tr>
<tr>
<td>slightly prefer the Physics 1A approach</td>
<td></td>
</tr>
<tr>
<td>strongly prefer the Physics 1A approach</td>
<td></td>
</tr>
</tbody>
</table>

- 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

<table>
<thead>
<tr>
<th>Year</th>
<th>&lt;g&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006-07</td>
<td>0.33(4)</td>
</tr>
<tr>
<td>2007-08</td>
<td>0.58(2)</td>
</tr>
<tr>
<td>2008-09</td>
<td>0.54(2)</td>
</tr>
<tr>
<td>2009-10</td>
<td>0.54(2)</td>
</tr>
<tr>
<td>2010-11</td>
<td>0.38(3)</td>
</tr>
<tr>
<td>2011-12</td>
<td>0.55(3)</td>
</tr>
<tr>
<td>2012-13</td>
<td>0.44(3)</td>
</tr>
<tr>
<td>2013-14</td>
<td>0.45</td>
</tr>
</tbody>
</table>

#### Post-test Scores

- Pre-test: n=161
- Post-test: n=161
Some perspective…

“a little bit disappointing” still twice as effective
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
How we scaffold PeerWise use

• 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’

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

- Nice question! A more interesting conservation of momentum question, and Richie Gray was involved so that always a bonus! (by: [Author has: 2317 points and 13 badges])

- Good question, still doesn't help Scotland score any points though :) (by: [Author has: 2030 points and 20 badges])

- Good context, creates an exam-like feel. Thanks for reminding us that there's a negative! (by: [Author has: 721 points and 8 badges])

- Very good question, nice sporting incident aswell (by: [Author has: 946 points and 7 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: [Author has: 1385 points and 11 badges])

- Really liked the set up of the question, although could have added unnecessary data as distracters. (by: [Author has: 453 points and 7 badges])

- You could have had the same answers with different signs to confuse people, but good question testing conservation of momentum! (by: [Author has: 1721 points and 10 badges])

- Nice question. (by: [Author has: 771 points and 9 badges])
Benefits for students

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) 1\textsuperscript{st} year 1\textsuperscript{st} semester

Physics 1B (Edinburgh) 1\textsuperscript{st} year 2\textsuperscript{nd} semester follow on from 1A

Physics 2 (Glasgow) 2\textsuperscript{nd} 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**: Exam score
**Independent Variable(s)**: MM, Pre-score before PeerWise use
Association between MM and exam score

Plot of standardized coefficients from regression analysis
… controlling for prior ability

Plot of standardized coefficients from regression analysis

- MM
- Pre-score
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”

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

<table>
<thead>
<tr>
<th>Agree / strongly agree</th>
<th>Disagree / strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>12%</td>
<td>77%</td>
</tr>
<tr>
<td>If I didn’t have to teach, I wouldn’t</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Agreement</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching is the most useful thing I do as an academic</td>
<td>26%</td>
</tr>
<tr>
<td>I take as much professional pride in my teaching as I do in my research</td>
<td>84%</td>
</tr>
</tbody>
</table>

Teaching staff are dedicated and engaged

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


• 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.

L. Deslauriers, E. Schelew, and C. Wieman, Science 332, 862 (2011)
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.


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

Implementation in practice

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

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

• Extensive use of student test performance (by staff) and student evaluations (by institutions) to evaluate effectiveness (USA study)
  
Example: Peer Instruction

1. Pose question
2. Students re-vote
3. Students discuss amongst themselves
4. Students re-vote
5. Whole class discussion
6. Continue to summarise
Implementing change

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

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)
Summary

• 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