Peer Instruction observed in the wild

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Outline
- Context and P.I.
- Class outcomes
- Smart pens
- Student conversations
- Revisions to teaching resources
- Summary and conclusions

Context

School of Physics & Astronomy
Context

Scottish undergraduate degree system:
- Bachelors degree in 4 years
- Masters degree in 5 years

First year calculus-based introductory physics course
- Newtonian mechanics (1st semester)
- Modern physics (2nd semester)

250-300 students
- 80:20 male and female
- 75:25 British and non-British students
- Mixed cohort (50:50 majors and non-majors)

Context

"Flipped" or "inverted" classroom approach

Class time

Private study time

Preparation

P.I. Lectures

Workshop

Peer Instruction

Eric Mazur, Harvard University
Publisher: Addison-Wesley
Traditional methods vs. Interactive-engagement


\[ \langle g \rangle = 0.45 \]
FCI diagnostic test results

\[
\langle g \rangle = 0.52
\]

Repeatability

<table>
<thead>
<tr>
<th>Course</th>
<th>Average P.I. gain</th>
<th>Diagnostic test gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sem 1, 2011-12</td>
<td>0.45</td>
<td>0.52</td>
</tr>
<tr>
<td>Sem 2, 2011-12</td>
<td>0.42</td>
<td>-</td>
</tr>
<tr>
<td>Sem 1, 2012-13</td>
<td>0.50</td>
<td>0.51</td>
</tr>
<tr>
<td>Sem 2, 2012-13</td>
<td>0.47</td>
<td>-</td>
</tr>
</tbody>
</table>

Smart pen

Ballpoint pen with integral digitiser and microphone. Captures penstrokes and audio recording in sync.

Advantages
- Easy to use
- Portable and convenient
- Relatively unobtrusive
- Capture speech and writing

Disadvantages
- No video
- Can be hard to identify speakers
Student conversations

19 student volunteers
Retained smart pens throughout semester
41 Peer Instruction questions posed
162 distinct Peer Instruction episodes captured

Volunteer student characteristics

Vertical lines show volunteer students
No significant differences to rest of cohort in:
- FCI results
- Course exam results
Volunteer students representative of whole class

“Learning is culturally shaped and defined: people develop their understandings of any enterprise from their participation in the ‘community of practice’ within which that enterprise is practised”

Schoenfeld (1992)

Previous studies, e.g. Nielsen & Stav (2012) and James & Willoughby (2011), find many P.I. discussions not aligned with expectations.

James et al. (2008):
- Discourse bias study.
- Categorised student ideas and conversation dynamics.
- Simple word counting was most reliable indicator.
Student conversations

Our data set:

- Full-cycle P.I. episodes
- Student discussion recordings
- Matched student voting records

Methodology

Examine recordings

Identify technical words (spoken & written)

Determine:
- Total number of technical words uttered
- Number of different technical words used
- Technical word 'h-index'

Double-coding to check for inter-rater reliability

Match student recordings to clicker votes

Determine correctness of pre- and post-votes

Classify discussions as
- right-right (RR) ✓
- wrong-right (WR) ✓
- wrong-wrong (WW) —
- right-wrong (RW) ×
- …etc.

Number of technical words uttered
**Summary**

*No* significant differences between numbers of conversations in each correctness category for:

- Total number of technical words uttered
- Number of different technical words used
- Technical word ‘h-index’

Success of P.I. episode **not** dependent on technical fluency of discussion.

**From the instructor’s perspective: Closing the loop**

Which one of the following is NOT a true statement about the frictional force acting on a block on a rough surface?

1. The frictional force is given by $\mu_k F_N$ if the block is accelerating.
2. The frictional force is given by $\mu_k F_N$ if the block is stationary.
3. The frictional force can be less than either $\mu_k F_N$ or $\mu_s F_N$. 
Problems with the question

- Negative question
- Confusion over symbols
- Focus on static vs. kinetic friction
- Focus on stationary vs. moving block
- Symbols activate formula-based approach

Revised question

A box of weight 100 N rests on a rough surface. The coefficient of static friction between the box and surface is 0.5. If push on the box with a force of 20 N, what is the magnitude of the force of friction exerted on the box by the surface?

1. 20 N
2. 30 N
3. 50 N

\( \langle g \rangle = 0.09 \)

Revised question

Pushing a Box (pre-discussion)

- Accepted
- Correct
- Incorrect

\( \langle g \rangle = 0.51 \)
Revised question

A box of weight 60 kg slides on a rough surface. The coefficient of static friction between the box and surface is 0.5. How much friction acts on the box if it is at rest?

1. 0 N
2. 30 N
3. 70 N

Still not perfect:
- Numerical values activate formula-based approach

But a big improvement

Summary

- Smart pen technology is highly effective for observing Peer Instruction “in the wild”
- Success (or otherwise) of P.I. episodes apparently independent of technical fluency of student discourse
- Smart pen recordings can give insight into impact of question characteristics on P.I. discussion
- Allows successful refinement of teaching materials