PeerWise

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1. What is PeerWise?

PeerWise (http://peerwise.cs.auckland.ac.nz/) is an online repository that students use to create and review multiple choice questions (MCQs).

Students are required to explain the answers to the questions they write and in doing so develop a deeper understanding of course-related assessment questions. Their understanding of the course material is further reinforced by answering and discussing the questions created by their peers.

Students are challenged to author questions that require them to focus on the important concepts and learning outcomes of a course. Developing effective alternatives encourages students to reflect on possible misconceptions, and explaining the answer to a question in their own words reinforces understanding.

2. PeerWise as feedback

Students receive immediate feedback when answering questions, including a summary of previously submitted answers. Answered questions can be evaluated for quality and difficulty, and associated discussion threads enable peer-dialogue around each question. Students can request help from their peers, and can improve question explanations.

3. Using PeerWise in teaching

Worldwide, PeerWise is used in a wide range of subjects, including Anthropology, Biology, Chemistry, Computer Science, Physics, Population Health, Pharmacology, Medicine, and many more.

PeerWise is free and very easy to use. Students are presented with a simple, intuitive interface and instructors can easily view student content and monitor participation.

4. PeerWise in Physics and Astronomy at Edinburgh

In 2010/11, scaffolded tasks using PeerWise were set as assessed assignments in two introductory-level physics courses.

In the pre-Honours course Physics 1A (Foundations of Physics), an exercise lasting 10 days replaced an assignment and contributing a small percentage of marks to the overall grade for the course. All of the 200 students who were enrolled on the course and required to complete assignments registered themselves with PeerWise and participated to some extent, with 165 (83%) completing the task set. The 200 Physics 1A students submitted 347 questions in total. They answered 3258 questions submitted by their peers and contributed 1903 comments. The 188 Physics 1B students submitted 346 questions in total. In addition, they answered 4065 questions submitted by their peers and contributed 2314 comments.

PeerWise was also made available to students preparing for the Senior Honours Physic Skills examination. No marks were available for participation and the uptake was 41 out of 123 students (33%). There was a better uptake in the Computer Simulations course (75%) but the participation of the 30 students was minimal leading us to conclude that 30 is below the critical mass for a successful PeerWise course.

5. Pedagogy

In physics, the main reason for adopting a system like Peerwise is to move students from acquiring information to using knowledge to reason and to solve problems. This addresses the recognised problem of students' over-reliance on memorised solutions developed during previous stages of education. We would also hope for changes in motivation and attitudes. In addition, students will engage in tasks in an innovative setting to develop metacognitive awareness and effective learning strategies that are self-regulated rather than externally driven (Nicol, 2009).

Whether from the perspective of information processing or social constructivism, it might be expected that PeerWise would have a positive effect on problem-solving ability and aid comprehension because it provides extra opportunities to do multiple choice questions. In other words, there will be a coaching effect. For those of higher ability, destined for lecturing in academia, there may also be the motivational effect of the task being seen as authentic.

From a social constructivist viewpoint, learners using PeerWise receive feedback from expert physicists and from other students and it can be argued that students interacting with an environment that encourages and facilitate self-regulated working are more likely to be working in their 'zone of proximal development.'

Vygotsky stated that a learner follows an expert's example and gradually develops the ability to do certain tasks without help or assistance. Vygotsky defines the zone of proximal development as "*...the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers* (Vygotsky, 1978, p. 86)."

For those of middle ability, who benefit proportionally less from the coaching effect than those of low ability and lack the metacognitive awareness and self-regulated motivation of those in the higher quartile, the chief problem may be that students are not operating in an appropriate zone of proximal development. Some may be setting the bar too low and operating at a level that gives a sense of task completion but provides no challenge. Others may be attempting to write questions at a level that is beyond that which can be successfully supported by their peers. The solutions to this are guidance to identify the zone and then increased scaffolding or more conflict, depending on whether you think the learning is evolutionary or revolutionary.

6. Scaffolding

In response to the challenge set in the conclusion of Denny *et al.* (2008), we inserted four scaffolding activities into the workshop preceding the PeerWise assignment.

1. A fun quiz that taught the language of MCQs (stem, options, key, distracters) and demonstrated how poorly written questions sometimes test nothing but language skills.
2. A pop quiz helped students to explore their beliefs about thinking and guided them toward learning orientation and away from performance orientation.
3. A question template introduced students to something we called the ‘blue zone’, probably better known as Vygotsky’s ‘Zone of Proximal Development.’ This simplified constructivist model, along with information about common misconceptions and errors, encouraged the students to author questions of high cognitive value.

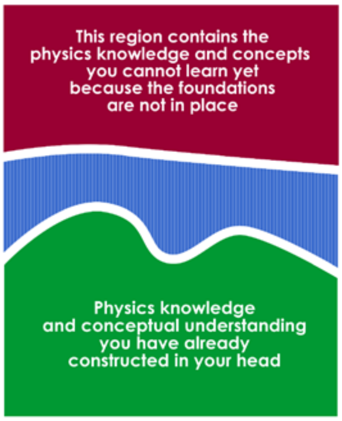

Figure 1 Zone of Proximal Development

4. An example question based on the template set the bar for creativity and complexity very high.

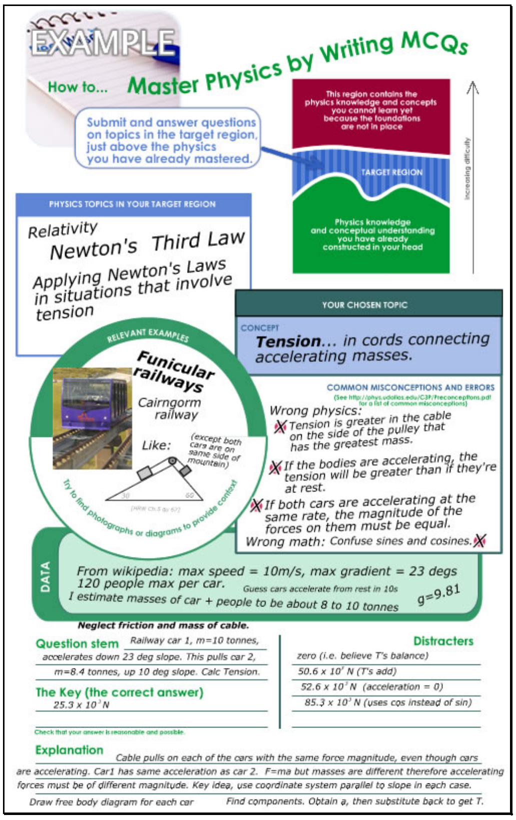

Figure 2 The example question used in the introductory workshops

Time in the workshop was allocated for the group authoring of a question and class leaders reported markedly increased levels of engagement in workshop session compared to those seen in standard problem solving tasks.

The average quality of the submitted questions was very good with few trivial questions or nonsense distracters. 'Community moderation' discouraged sub-par questions.

In the post-course survey of Physics 1A students, 65% agreed that developing original questions improved their understanding of course topics.

"The biggest benefit was writing question and having to put a lot of thought in to explain the problem to other people. It really helped my understanding of parts of the subject."

7. Is PeerWise inclusive?

During implementation, participation rates, the quality of submissions and the sensitivities surrounding formative peer feedback were monitored carefully but unobtrusively. Project evaluation has resulted in small modifications to the resources are planned for the coming year.

Learner autonomy is inherent in PeerWise. The students own the working space and moderate the discussions and interactions themselves with minimal supervision by lecturers and Teaching Assistants.

The multimedia nature of the PeerWise authoring space provides automatic or on-demand dual coding with semantic equivalence. PeerWise is a web-based application that runs directly in a browser without plugins and can therefore take advantage of all the accessibility functionality provided by modern browsers.

Statistical analysis during and after the courses provided clear evidence that PeerWise and our scaffolding interventions were gender neutral and did not disadvantage students for whom English is not their first language. The team was prepared to provide technical solutions for those without graphics authoring software but this proved unnecessary. During the next phase, we will encourage a shift towards SVG standards so that web browsers can easily rescale the diagrams.

8. Does PeerWise enhance learning?

Active use of PeerWise is reported to be strongly positively correlated to students' grades (Denny *et al.*, 2008). In the same paper, the authors of the system observe that the improvement is seen in both the multiple choice and written sections of the final examination and argue that this implies deep learning as opposed to drill-and-practice coaching leading to better MCQ technique.

Time-on-task and levels of engagement are strong predictors of success with some students gaining a great deal of confidence and self-esteem from the peer feedback they received. The PeerWise application contains a scoring and badge system and many students found these features motivating.

"It made answering physics questions a lot more fun and the points system made it competitive which made you want to do more."

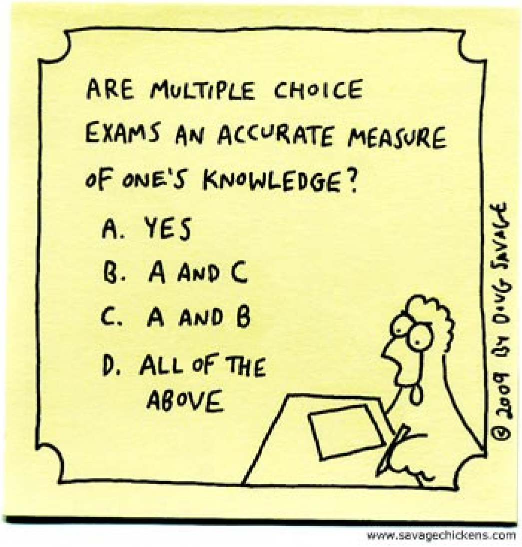

Figure 3 - Cartoon used by kind permission of Doug Savage

Figure 3 shows the number of contributed answers as a function of time for the Physics 1B course. The assessment deadline was 25th March 2011 and, unsurprisingly, student usage peaked around this time (although not as sharply as has been observed in some other studies, with an order of magnitude increase in activity immediately prior to a deadline) Usage at a lower level continued during the revision period and up to the date of the final examination (6th May 2011) even though there are no MCQ questions on the final examination paper.

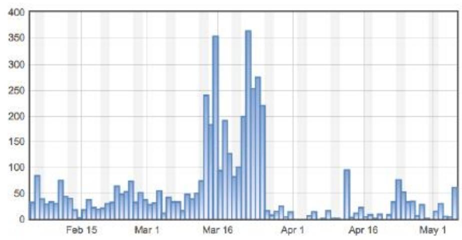

Figure 4 Number of questions answered as a function of time

The quality of student contributions was very high, and in some cases, truly exceptional. The overwhelming majority of questions contributed during the first assessment focused on quantitative problem solving (usually with a context, often humorous).

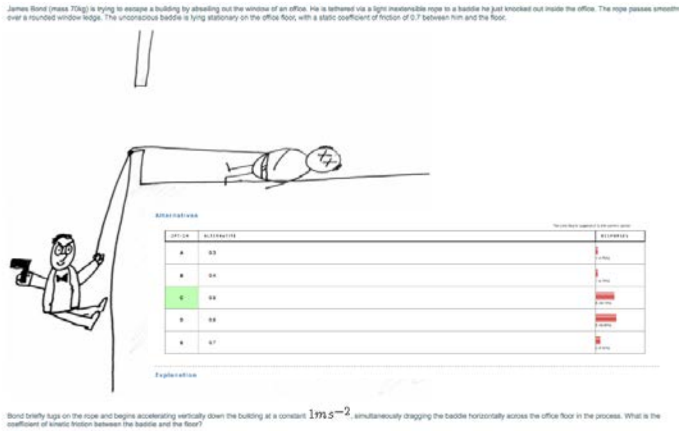

Figure 5 An example of a question with an inventive context

In the second semester, there was a greater proportion of more conceptual questions. This may be a consequence of the content of the respective courses: Physics 1A is a mechanics course, and the students seemed able to invent richly contextualised questions based on real-world situations; in contrast, Physics 1B focuses more on modern physics, a context in which the students seemed less inclined to set extended, quantitative problems. In both assignments, students made extensive use of mathematical notation entered through the built-in equation editor interface.

Using the methodology of Denny (Denny *et al.*, 2008, p.2272), we investigated the ways in which use and engagement with PeerWise may be correlated with end of course performance. We are careful to separate out correlation and causation: we are only able to seek evidence for the former and cannot isolate the latter using the published methodology. We performed a median split of the class for the PeerWise assessments on the basis of activity on the system, separating students into categories of High PeerWise Activity (HPA) and Low PeerWise Activity (LPA), for values that were above / below the median value for that assignment. We then looked to see if there were any differences in mean mark on the end of course examination for these cohorts.

Table 1. A comparison of end of course exam mark with PeerWise activity level.

Cohort	Number of students	Mean exam score*	Standard error	p value	Effect size†
1A	(N=193)				
HPA**	104	63.2	1.6		
LPA	89	53.6	1.6	<0.001	0.29
1B	(N=182)				
HPA	94	61.9	1.8		
LPA	88	46.8	2.4	<0.001	0.36

* all scores expressed as percentages
† Pearson's r
** HPA / LPA denote higher / lower than median PeerWise activity

Our analysis supports the previous work by Denny showing that performance improvements as a result of using PeerWise are observed across all abilities but most consistently in the top (most able) and bottom quartiles. PeerWise may be of less benefit to mid-ability students (Denny *et al.*, 2008).

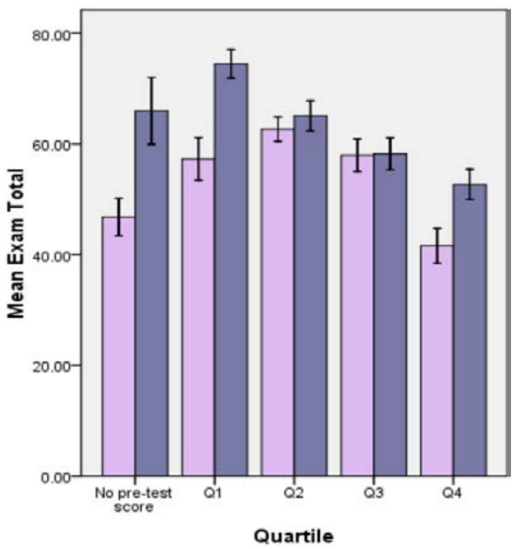

Figure 6 A comparison of mean exam total for each quartile (Q1 = top quartile) as determined from the students' FCI test scores. The pink (pale) bars represent the students with Lower-than-median PeerWise Activity (LPA) and the blue (darker) bars represent the students with Higher-than-median PeerWise Activity for that quartile. The fifth 'quartile' is made up of students who did not take the FCI test.

9. Discussion

A strong instructional design approach based on constructivist principles may go some way to explain why our implementations of PeerWise have produced clearer correlations between activity and learning than have been reported by some other institutions.

The design process began with the identification of PeerWise in the literature as an application likely to move students from acquiring information to using knowledge to reason and solve problems.

One of the early reports (e.g., Denny et al., 2008) identified a need to scaffold students who the lacked metacognitive awareness. We determined that teaching interventions likely to be of cognitive benefit would be those that facilitated conflict and debate in an environment where it was safe for students to make mistakes and errors.

PeerWise has had a measurable impact on learning and teaching in our introductory physics courses. Quantitative evaluations including matched-pairs analysis show moderate to strong correlations between measures students' PeerWise activity levels and summative course exam results.

In using this tool to assess each other's understanding, students were activated to create learning resources for the class and to participate in online discussions and collaborations. The emphasis on multi-stage mathematical problem solving meant that the criteria for success in physics courses became clearer to students. In addition, question topics had to be within the syllabus, encouraging students to become more familiar with the published learning outcomes.

Students became aware that naïve ideas and misconceptions (and ways addressing them) are intrinsic to their journey towards mastery in the physics domain and are not merely mistakes, errors or lack of learning. This is evident in the evolution of so many high-quality questions, many of which retained rich contexts through a number of design iterations while having the mathematical complexity pruned out. High quality online discussions often led to self-correction of misconceptions initially present in the questions, answers and explanations. The students also developed a better understanding of how physics questions are constructed and why they often seem to be set in a simplified universe where objects are spherical and friction does not exist.

Figure 7 The scaffolded implementation of PeerWise by the School of Physics and Astronomy at The University of Edinburgh was awarded the Formative e-Assessment prize at the Scottish e-Assessment Conference, 2011.

Students received immediate feedback when answering questions, including a summary of previously submitted answers, and could request help from their peers in order to improve question explanations. By encouraging deep conceptual learning, the PeerWise resource created by each class has reduced the need and temptation to rely on last minute cramming for summative assessments while, at the same time, producing a valuable bank of revision questions.

The analysis method adopted by Denny (t-tests of mean exam marks of median splits of quartiles) is well suited for large cohorts where $N > 800$. Despite having smaller classes, $N \approx 200$, we have nevertheless adopted the Denny methodology in order to compare our experience with the published literature. We now intend to develop a methodology more suited to modest class sizes based on matched pair analyses. Exploratory studies suggest that if we compare the learning outcomes of groups of students who are matched with respect to entry qualifications, gender, coursework marks and other relevant factors we may be able to isolate the effectiveness of PeerWise. A preliminary study suggests that full engagement with PeerWise in a course results in a gain of between 5% and 10% on end-of-course summative measures. In many cases, this makes a difference of a grade point.

10. Acknowledgements

We gratefully acknowledge funding from JISC Assessment and Feedback Strand B, departmental development project grant support from the Higher Education Academy UK Physical Sciences Centre and the support of Paul Denny, University of Auckland.

11. Links

If you are interested in using PeerWise, or if you have any questions, please contact the PeerWise web site:
http://peerwise.cs.auckland.ac.nz/
(last accessed 13 September 2011).

A pack of the scaffolding resources used in the Edinburgh Physics and Astronomy implementation of PeerWise can be downloaded from the EdPER website:
http://sites.google.com/site/edpersite/project-updates/scottishe-assessmentawardwinner2011formativeassessment/Scaffolding.zip?attredirects=0&d=1

JISC Assessment and Feedback Strand B:
http://www.jisc.ac.uk/whatwedo/programmes/elearning/assessmentandfeedback.aspx

12. References

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