

Students sharing and evaluating MCQs in a large first year Engineering course

Paul Denny, John Hamer, Andrew Luxton-Reilly

The University of Auckland, Auckland, New Zealand

{paul,j.hamer,andrew}@cs.auckland.ac.nz

***Abstract:** Actively engaging students in the production of a repository of multiple-choice questions that can be used for self-assessment and revision is an innovative way of enhancing students learning. In this paper, we report on our experiences in using such an activity in a large first year Engineering course, illustrating examples of student generated content and investigating student perceptions of the task. We believe that this activity has the potential to contribute widely to Engineering Education practice, providing a study resource that is valued by students with almost no cost to teaching staff.*

What is PeerWise

Multiple-choice questions (MCQs) are a convenient means of evaluating learning (Woodford 2004), and, when corrective feedback is provided, they can convert mistakes into new learning (Epstein 2002). This latter process is the focus of PeerWise, a web-based tool that provides a framework for students to work collaboratively with their classmates to *create* a large repository of multiple-choice questions for use in revision (Hamer, 2008). By creating the question bank, rather than just accessing an existing one, a number of new opportunities for learning arise. In order to create a question, a student must: *reflect* on the learning outcomes of the course; consider *misconceptions* when proposing distracters (i.e. plausible, yet incorrect, answers); and understand the topic in sufficient *depth* to write an explanation for the correct answer. Once questions have been submitted, other students in the course can use the repository for self-assessment, learn from the explanations, evaluate the quality of the questions, and participate in discussions by offering additional explanations or posting comments directly to the author. By establishing a learning community that incorporates active learning, peer review, and peer tutoring, PeerWise has the potential to be a powerful teaching tool. Previous work has shown significant correlations between PeerWise usage and exam performance (Denny et al. 2008c).

When a student logs in to PeerWise, they are shown a menu divided into three sections: the questions that the student has contributed; the questions which have been created by others and which the student has answered; and the questions which have been created by others but which the student has not yet answered (Figure 1a). Each of these sections is discussed briefly next.

Your questions

All the questions a student has contributed are displayed in a table, which includes information such as when the question was created, how many times it has been answered, and the current rating and difficulty of the question as assessed by students who have answered it (Figure 1b).

The details of a question can be viewed by selecting it from the table. This includes the question text, as well as a histogram showing how often each alternative has been selected, and any feedback that has been provided by other students. Question authors are able to write a response to any feedback written about their questions.

Contributing a new question involves providing a question stem and between two and five alternatives. The question author indicates which of the alternatives is correct, and provides an explanation for the answer. The explanation is displayed to all students upon answering the question, and is intended to assist students who have answered the question incorrectly to understand their mistake. Question contributors are able to "tag" their questions to indicate relevant topics. The tags

are presented in a cloud that enables students to quickly locate questions on topics of interest. As soon as a new question is contributed, it immediately becomes available in the "Unanswered questions" section for all other students in the course.

(a) Main menu for PeerWise showing sections for 'Your questions', 'Answered questions', and 'Unanswered questions'.

(b) 'Your questions' table showing a list of questions with columns for Question, Suitability, Difficulty, Created, Responses, and Rating.

QUESTION	SUITABILITY	DIFFICULTY	CREATED	RESPONSES	RATING
1 View	OK	easy/medium	4:52pm, 30 Sep	24	3.0000
2 View	OK	medium	1:50pm, 30 Sep	30	3.5455
3 View	!	easy/medium	3:59pm, 23 Sep	18	2.6923
4 View	OK	easy/medium	6:32pm, 19 Sep	96	3.6000

Figure 1: The main menu for PeerWise (a) and the “Your questions” table (b)

We have examined the questions contributed to a repository in a course where students were given no guidance or incentive (Denny et al. 2009), and found a good level of coverage for all major topics. We concluded that, in a suitably large class and with well-motivated students, a broad question repository can emerge without the need to provide any explicit direction to students.

Unanswered questions

Every student has access to all of the questions contributed by their classmates, which are displayed anonymously. Unanswered questions are presented in a table, along with a quality and difficulty rating and the number of times the question has been answered, from which the student can select individual questions to answer. Once a student selects an answer to a question, they are shown the answer suggested by the question author, and the number of times each alternative was selected by other students in the course. The explanation provided by the author is also displayed, as are all student comments written about the question. Students are encouraged to re-evaluate their answer in the context of all of this feedback, and can rate the quality (0–5) and difficulty (easy/medium/difficult) of the question, as well as contribute to the discussion thread.

Answered questions

All of the questions a student has answered are displayed in a table in the "Answered questions" section. If a student has provided feedback on a question, they can check to see if the author has responded to their feedback in this section, and they can monitor how other students answer these questions.

Teaching context

The Bachelor of Engineering degree at the University of Auckland is a four-year program, the first year of which has been taught entirely in-house since a university-wide structural change in 1996 (Godfrey, 2009). The Engineering Computation and Software Development course (ENGGEN 131) is a compulsory course for all first year Engineering students, and introduces students to MATLAB in the first 6 weeks and C programming in the second 6 weeks.

In this paper we will report on the use of PeerWise in 2008 in both the MATLAB module (6 weeks) and the subsequent C module (6 weeks) of the 12 week ENGGEN131 course. Students were offered a total of 7% of their final mark, split evenly between the MATLAB and C sections of the course, for participation with PeerWise. To gain the 3.5% participation mark for the MATLAB section of the course, students were required to contribute 2 questions and answer 10 questions. For the C section of

the course, students were required to contribute 2 questions and to answer 20 questions to collect the 3.5%.

Over the 12 week period, the 574 students in the course contributed 2,569 questions to the repository (4.4 per student), and submitted 53,311 answers (93 per student) and 5,221 comments to these questions (9.1 per student).

Student feedback and results

PeerWise was used for the very first time in the ENGGEN 131 course in 2007. On this occasion, it was used only by the students in the second half (C module) of the course. We conducted a post-course survey to examine student perceptions of the PeerWise activity, and the generally positive results of this survey were one of the driving forces behind the adoption of PeerWise in both modules of the course in 2008. In this section, we summarise the results of the 2007 survey.

In addition to an open-ended response item, students were asked to rate their agreement to each of the following statements on a standard Likert scale: Q1="Developing new questions helped me learn", Q2="Answering other student's questions helped me learn" and Q3="I would like to use PeerWise next year". The results, which were largely positive, are presented in Table 1.

Table 1: Student responses to survey questions

	SD	D	N	A	SA
Q1	2	12	61	201	149
Q2	2	13	54	188	168
Q3	7	12	79	161	166

The open-ended response yielded many encouraging comments, including:

"Wow, what can I say, Peerwise is one of the best learning tools I have used. The neat thing is encouraging the Peerwise community, in a similar fashion to social networking sites, by allowing feedback to be provided; and utilising a leaderboard. It is the sort of thing that gets people addicted to Peerwise."

"Setting up my multi-choice question was pretty hard given that i had to think of the possible wrong solutions students would fall for and required alot of thinking from me, which in the end was a lot of help because i was just about able to answer any question that was on the same topic as my question. That was the biggest learning experience for me!"

The critical comments were generally constructive:

"A lot of boring and familiar questions with not much effort. However, the rating system really helps to deal with this as you can filter out crap questions."

"People feel obligated to give five answers when there is the option of adding five answers. Most of the time 1 or 2 answers are not very plausible and just there to fill in the spaces"

"I was reluctant to answer other people's questions simply because of the lack of professional layout. I think there needs to be some emphasis on layout and grammar"

Examples of content

Examination of the repository of questions developed by students in the 2008 course uncovered a number of interesting questions and comments. There were many examples where students put noticeable effort into the wording of their questions, perhaps in an attempt to make them more appealing to other students. For example:

Jeff and Liz are both doing ENGGEN131. Jeff is too shy to ask Liz out, so being a total geek, he sneaks on Liz's computer while she's out of the room and types up the following code into a new m-file:

```

answer = {'yes'; 'no'}; %line 1
question = input('Would you like to meet up for coffee? '); %line 2
if strcmpi(question, answer{1})==1 %line 3
    disp('Great! I will see you tomorrow morning at 10 in Starbucks!') %line 4
elseif strcmpi(question, answer{2})==1 %line 5
    disp(':(') %line 6
end %line 7

```

Unfortunately Jeff didn't have enough time to test his code before running his script file in matlab. When Liz answered, an error message popped up. Which line of the code is the error on?

The author of this question contributed seven other questions to the repository, three of which continued using "Jeff" and "Liz" as part of a background story. These questions were all highly rated (greater than 3.6/5) and comments indicated that they were appreciated by other students:

"i think jeff and liz questions are well written and excellent...not to mention entertaining lol"

The discussion threads (comments) provide an additional source of learning material. In some cases, the comments were used to help clarify misunderstandings. For example, in a question that made use of the modulo operator, a student posted the following comment about the question:

```

if ((j % num) == 0)
    wat does the % do??

```

to which the author of the question provided the following response:

% is the modulus division operator. It divides j by num, but instead of giving the quotient like normal dividing, it returns the remainder. The overall statement checks that (j / num) has a remainder of zero; i.e. that j is a multiple of num. For more information on modulus division, see page 22 in the course book.

Quantifying success

We analysed data collected from this activity to answer two questions of interest to us:

- 1) Do students value the repository created by their peers?
- 2) Do student ratings add to the usefulness of the repository?

In the analysis of this section, we only consider students who sat the final exam for the course (556 of the 574 enrolled).

Repository value

One way to measure whether students value the resource is to look for voluntary usage. Answering more questions than they are required, or using the repository for revising for the final exam, would indicate that students do indeed find the peer-created resource useful.

The last day of the semester was the 24th of October and the final exam for this course was on the 5th of November. A substantial portion of the class used the repository for exam revision during the study break, as shown in Table 2. The mean and median contributions (until the final exam) in each repository are summarised in Table 3. The higher than required usage observed in this context is in agreement with earlier results (Denny et al., 2008a, 2008b) in an introductory programming course in Computer Science.

Table 2: Students using repository voluntarily for review

	<i>MATLAB</i>	<i>C</i>
number of students	185	166
percentage of class	33%	30%

Table 3: Mean and median question and answer contributions per student

	<i>MATLAB</i>		<i>C</i>		<i>Combined</i>	
	questions	answers	questions	answers	questions	answers
Requirement	2	10	2	20	4	30
Mean	2.27	58.2	2.15	34.7	4.42	92.9
Median	2	36	2	25	4	63.5

Student ratings

Previous work has shown that student ratings of questions agree quite well with instructor ratings of the same questions, and that questions with higher ratings tend to be answered more frequently, indicating that students rely on the ratings of their peers when determining which questions to answer (Denny et al., 2009a).

Figure 2a shows a plot, for each of the 2,569 questions, of the number of times the question was answered against the average rating of the question. It is interesting to note on this chart a collection of 22 questions that became highly popular. There is a good explanation for this group of outliers. All but one of these questions was contributed by the lecturer of the course. Although all activity on PeerWise is anonymous, in this particular case the lecturer signed her name to the questions she contributed. A feature on PeerWise allows students to find all other questions written by the author of a particular question, so once they had answered one of the lecturer's questions they were easily able to find the others.

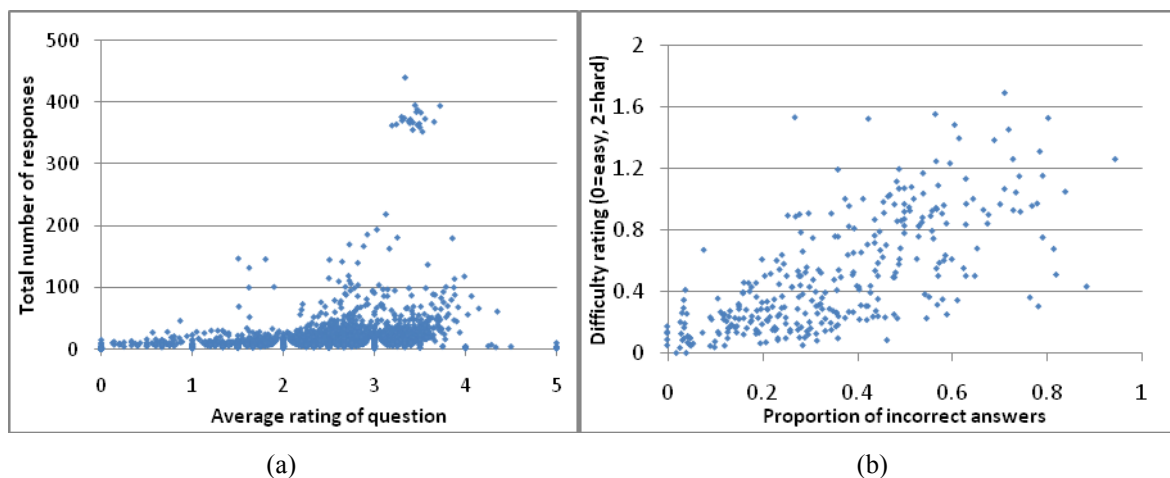


Figure 2: The number of responses with respect to average question rating (a) and perceived level of difficulty compared with the measured difficulty (b)

Even aside from this, there is a clear trend evident in Figure 2a that as the rating of a question increases, so does the likelihood that it will be responded to.

Students also rate each question they answer for difficulty (on a scale of 0=easy, 1=medium, 2=difficult). An objective measure of difficulty is the percentage of responses to a given question that are correct (for the purposes of this analysis, we define correctness as “the response agrees with the suggested answer of the question author”). Figure 2b shows a plot, for each question, of the average difficulty rating against the proportion of incorrect responses. Only questions with at least 20 difficulty ratings or more are shown. There is a very clear trend in this data ($R=+0.69$), indicating that student difficulty ratings (which are shared with all students on PeerWise and can be used to decide which questions to answer) do accurately represent the difficulty of the question. Collectively, the question quality and difficulty ratings can be used by students to choose which questions to answer and hence add to the usefulness of the repository.

Conclusions

The PeerWise system allows students to contribute to the learning of others by actively engaging in the co-production of a repository of multiple choice questions that can be used for self-assessment and revision. We have previously reported on the use of PeerWise in a standard CS1 course taught in Java to Computer Science majors. Here we investigate whether the system is effective in an Engineering context in which the majority of the class are not majors in Software Engineering.

We find a high correlation between student difficulty ratings and the number of times an incorrect answer is selected. We conclude that students are capable of making accurate judgements about the difficulty of questions. Students also make critical judgments about the quality of the question when they assign a rating. The higher rated questions tend to be answered more frequently than the lower rated questions, suggesting that students consider the ratings to be credible. We believe that the process of reflecting on assessment questions and making critical judgments about them is an important part of developing self-assessment skills which lead the way to life-long learning.

We also find that students make significant use of the repository during the revision period prior to final examinations. PeerWise use during this period is purely voluntary, so we conclude that students value the repository as a useful study resource. We believe that PeerWise has the potential to contribute widely to Engineering Education practice by providing a study resource that is valued by students with almost no cost to teaching staff.

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