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Web-Based Peer Tutoring in Science Education

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Abstract

Peer-instruction has been shown to have a very positive effect on students' engagement and learning. PeerWise is a web-tool designed to allow peer-tutoring between students within a large class group. Students can write, answer and discuss Multiple Choice Questions (MCQs) based on their work in-class. It is low-cost and low-maintenance software which has become increasingly popular across many subject disciplines as a method to introduce a peer-tutoring aspect to course work.

In this study we introduce PeerWise as a form of continuous assessment to a wide and varied cohort of science students (N=509) across disciplines, undergraduate years, levels (certificate to honours degree) and institutes. Correlations between engagement with PeerWise and an increase in end of module exam results are investigated and found to be strongly correlated in one of the modules investigated. Students' attitudes to PeerWise are probed with a number of Likert style questions. It is found that the students agree that the tool benefits their understanding through the peer-activities of authoring and answering questions and to a lesser degree by discussion of questions with classmates. Some differences exist between class groups but overall the engagement levels across all groups are much higher than the minimum requirement set by the assessments.

Keywords: peer instruction, science education, web tool

Introduction

Problem-solving is a highly important graduate attribute which is of particular importance within the scientific community. Students prepare for this by solving many "end-of-chapter" type questions. However, it has been argued that a much deeper understanding of the concepts can be gained by students if they are required to create their own questions (Draper 2009).

PeerWise creates a student-centred, predominantly student-regulated learning community based on web tools which the students are familiar with (Denny n.d.). Students are asked to create questions, provide answers and outline short explanations for their questions. All these tasks further raise their cognitive efforts and create deeper understanding. The students create a shared study tool which is focused on the module and its assessment related content.

Feedback is of the utmost importance to students but is highly demanding on staff workload. PeerWise has also been shown to be a very effective tool in facilitating peer-feedback (Hooper, Park and Gerondis 2011) which studies have indicated can have significant advantages to student learning and development (Nicol 2011). Active learning is promoted throughout not only by the actions of creating and answering questions but by the more subtle mechanisms of assessing their own work in the context of others.

PeerWise has shown promising first results when implemented in science education (Bates, Galloway and McBride 2011; Fitzgerald, Johnston and McClelland 2011; Ryan 2013). We propose to evaluate this very promising piece of technology in the development of students across a range of science courses in DIT and the University of Glasgow. We will measure staff and student attitudes to PeerWise and any gains in student's conceptual understanding.

Implementation of Project

We employed PeerWise across a wide and varied student cohort. It was implemented in a similar fashion in a number of different physics and chemistry classes across two institutes, Dublin Institute of Technology and the University of Glasgow, across different junior undergraduate years with a mixture of different qualifications' levels from advanced certificate (level 6) to honours degree (level 8). In total we introduced PeerWise into five modules as shown in Table 5.1. All lecturers agreed to implement PeerWise in a similar fashion. In our scaffolding material we followed an approach similar to that laid out in a 46 DIT Teaching Fellowship Reports 2013–2014

previous study (Casey et al. 2014). An introductory presentation and exercises focused on the pedagogy and rationale of the use of PeerWise rather than the mechanics of the software. Exercises highlighted methods of writing good MCQs in addition to incorporating distractors and common student mistakes into the possible answers. Examples of previous good PeerWise questions illustrated the potential to be creative, have fun and to use the authoring of questions as a learning exercise. We highlighted the anonymity and the fact that this was the students' learning space. This was to encourage students to be creative and to allow themselves and others to be comfortable in making mistakes. Examples of the scaffolding material can be found online (Denny 2014) with further details reported by the previous study (Casey et al. 2014).

Group #	Institute/school	Year/level	Module description	Active students
1	DIT/School of Physics	1/8	Introductory physics for non-physics degree courses	104
2	DIT/School of Physics	1/8	Introductory physics for physics degree courses	47
3	DIT/School of Food Science and the Environmental Health	1/8 and 6	Organic chemistry	141
4	DIT/School of Physics	1/7	Fundamental physics	78
5	UG/School of Physics and Astronomy	2/8	2nd year general physics	139

Table 5.1: Listings of the different class groups involved in study

Over the different modules the marks associated with PeerWise were in the region of 2–6%. Students are required to author, answer and comment on four questions each. Students gain a PeerWise score by engaging with PeerWise and this was incorporated into the marking scheme as shown in Table 5.2.

Description	Score (%)
Write, comment on and answer less than 2 questions	0
Write, comment on and answer more than 2 questions but less than 4	20
Write, comment on and answer 4 questions and get a PeerWise score less than the class average	40
Write, comment on and answer 4 questions and get a PeerWise score greater than the class average	70
Write, comment on and answer 4 questions and get a PeerWise score in the top ten students	100

Table 5.2: Scoring system in use for this implementation of PeerWise

This scoring system was decided upon to allow students to pass based on modest engagement and to encourage competition within the class for the engaged students. Previous efforts to grade students on a curve based on their PeerWise score were met with resistance from students (Casey et al. 2014).

Evaluation and Discussion

Pre and post exams

Previous studies have used quartile tests to show a correlation between student engagement and an increase in end of module exam results (Bates 2011; Hardy et al. 2014). Students sit a class test before the introduction of PeerWise and based on the results of this test are divided into quartiles. After this test PeerWise is introduced to the class and the assessment runs over typically a half semester timeframe. The PeerWise assessment date closes and sometime after that the students sit the end of module exam. The quartiles are then further subdivided into students with high PeerWise Activity (HPA) and Low PeerWise Activity (LPA). The average end of modules exams are plotted for each of the LPA and HPA groups for each quartile, results are shown in Figures 5.1 to 5.3. Error bars on these plots are the standard error.

Correlation as seen by previous studies (Bates 2011; Hardy et al. 2014) is not clearly shown in Figures 5.1 to 5.2; any gains or losses are within the error. In Figure 5.3 (Group 3), the Organic chemistry module, large gains can be seen across all quartiles. It is unclear why the difference in the different modules, and could be due to a number of reasons e.g. different lecturer engagement. A possible explanation could be the alignment of assessment in Group 3 as outlined in the report (Ryan 2013).

PeerWise usage data

As reported by many previous studies (Bates 2011; Ryan 2013; Casey et al. 2014; Hardy et al. 2014) the students engaged highly with PeerWise and contributed far more than was expected. For 509 students the minimum requirement would be 2,036 questions authored, answered and commented on. In total, students contributed almost double of the minimum required questions, over 24 times the minimum answer requirements and six times the minimum comment requirements. However this simple analysis does not account for the different student behaviour. From the data it is evident that a small portion of the students, approximately 25%, account for approximate 60% of the contributions to PeerWise. The majority of students do closer to the minimum requirement, authoring typically four questions and answering 4–10 questions. A low percentage, approximately 15% do not engage well and do less than the minimum requirement.

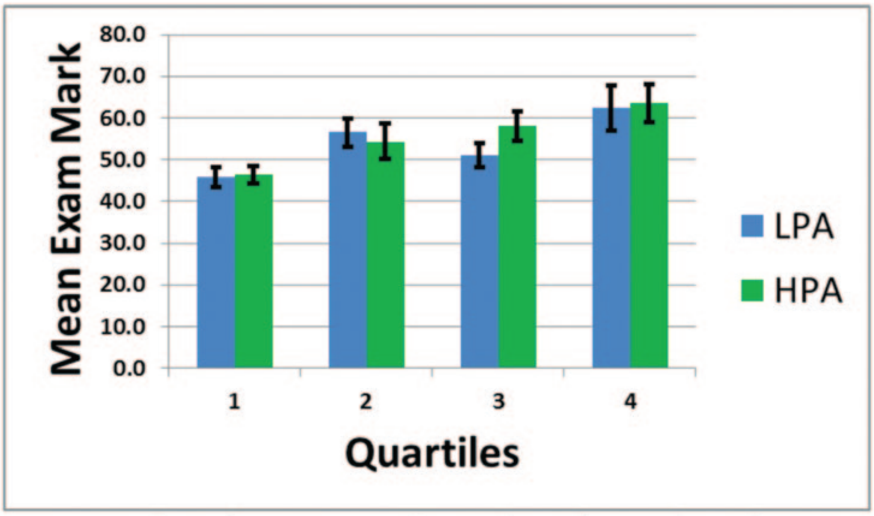

Figure 5.1: Quartile test for Group 1, Introductory physics for non-physics degree courses

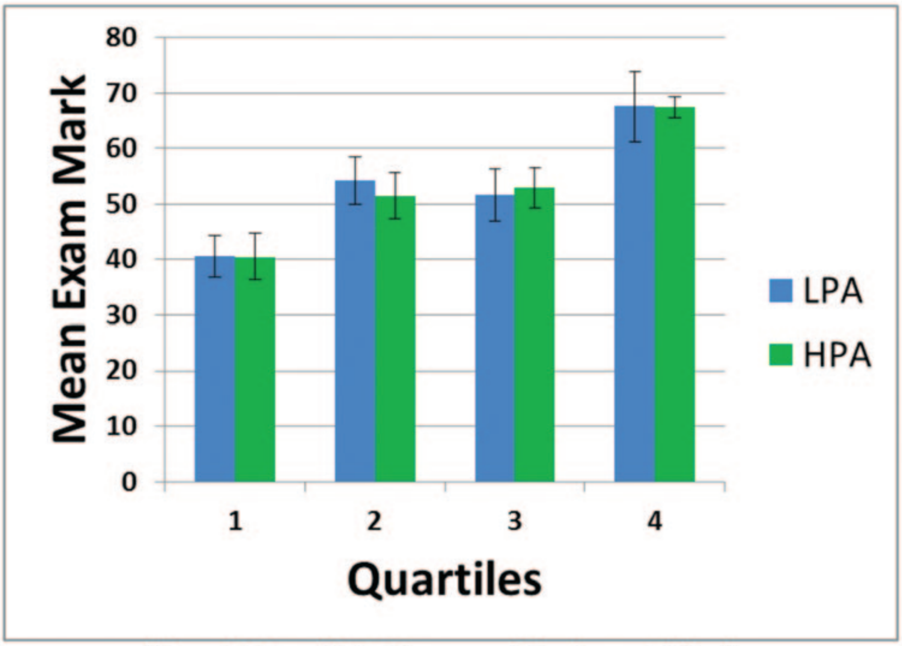

Figure 5.2: Quartile test for Group 4, Fundamental physics

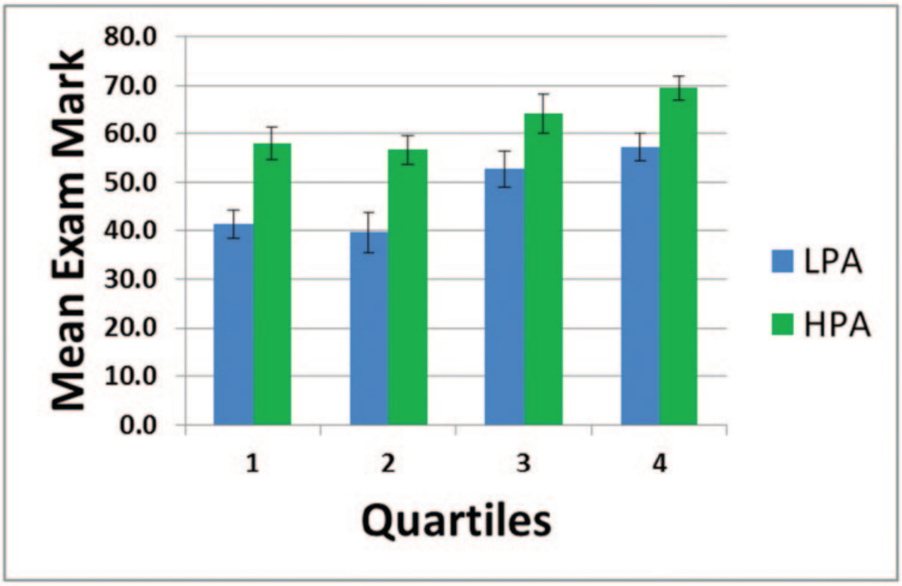

Figure 5.3: Quartile test for Group 3, Organic chemistry

Questionnaire

A questionnaire was designed to provide insight into the students' use of PeerWise and to probe their attitudes towards the software. The full questionnaire is included in Appendix C. It contained eight Likert-scale type questions and four free-text questions. Thematic analysis on the free-text responses is ongoing; here we report the results of the Likert type questions shown in Table 5.3.

Question #	Questions	Average student feedback
1	Developing original questions on course topics improved my understanding of those topics	Agree
2	Answering questions written by other students improved my understanding of those course topics	Agree
3	Engaging in discussions (writing and reading comments) improved my understanding of these topics	Neutral/agree
4	Of the questions I authored, I created them from scratch ("strongly disagree" here means you copied and pasted questions from other sources whereas "strongly agree" means you developed the question entirely on your own)	Agree
5	I did (or would) use PeerWise for exam preparation and/or revision	Agree/Strongly agree
6	I accessed PeerWise primarily from my mobile device (e.g. smartphone, tablet)	Strongly disagree
7	I would like to see PeerWise introduced for assessment in my other modules	Agree
8	Time taken for me to create a typical PeerWise question	10–30mins/0–10mins

Table 5.3: Questions with average student responses to Likert-scale questions

The students appeared to find writing and answering questions more useful than engaging in discussion. The spread of the answers across the different class groups were quite similar. When asked the question on plagiarism, the fourth question, differences appeared in the different class groups as shown in Figure 5.4. Here we attempted to probe the amount of plagiarism that was occurring. Class Groups 3 and 4 have a higher amount of plagiarism occurring with many more students' answers agree/strongly agree. Group 5 has the least amount of plagiarism. These groupings, Groups 3 and 4 on one side and Group 5 on the other form the outside poles in these answers; they also form the opposite poles in terms of academic level. Group 3 contained first year level 6 and level 8 students and Group 4 contained first year level 7 students. As opposed to this Group 5 had second year level 8 students. The other groups sit between these groups both academically and in their responses to the question.

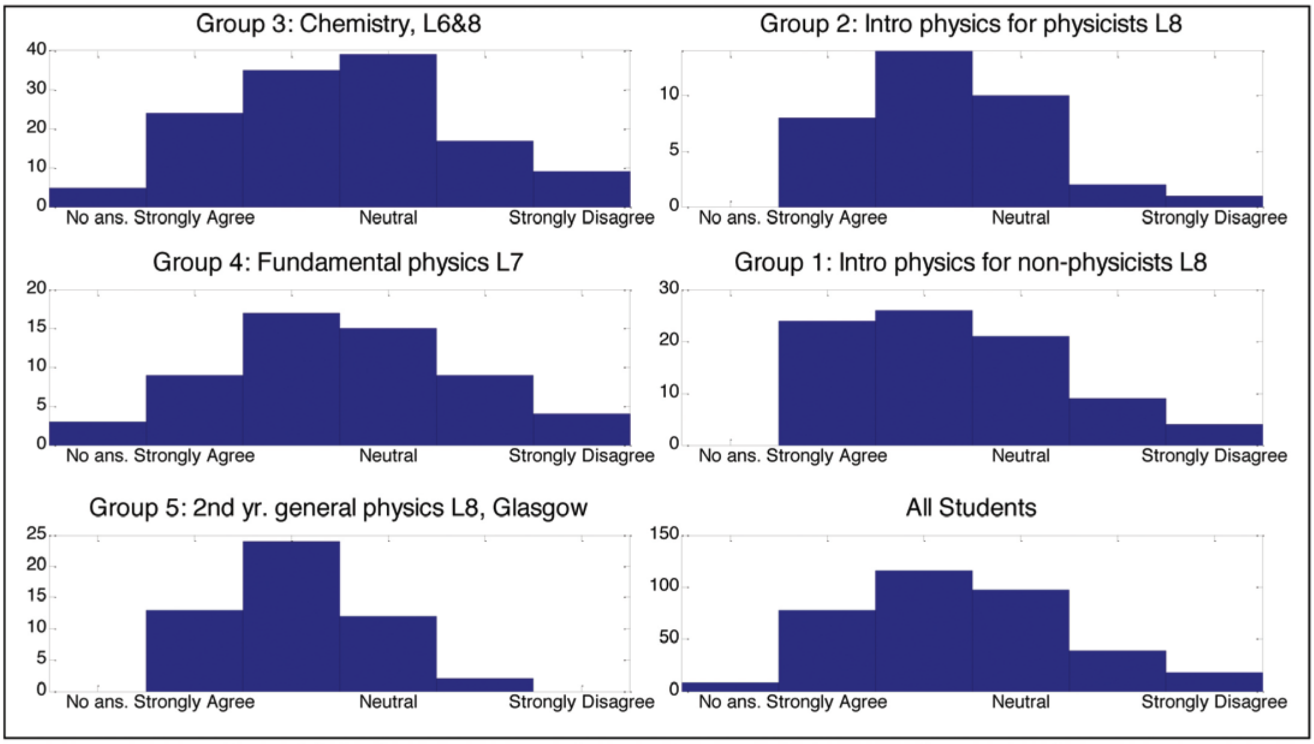

Figure 5.4: Student responses to the question on plagiarism, Question 4

Students agreed that they did or would use PeerWise for revision. In modules where exams occurred during the PeerWise assessment period, peaks in activity can be seen which coincide with exam dates. However after the PeerWise assessment date but before end of module exams very little, if any, activity was registered on PeerWise across all modules. However, when students sat exams throughout the PeerWise assessment dates peaks could be seen in the activity levels on PeerWise which corresponded to the exam dates. This is illustrated for Group 3 in Figure 5.5.

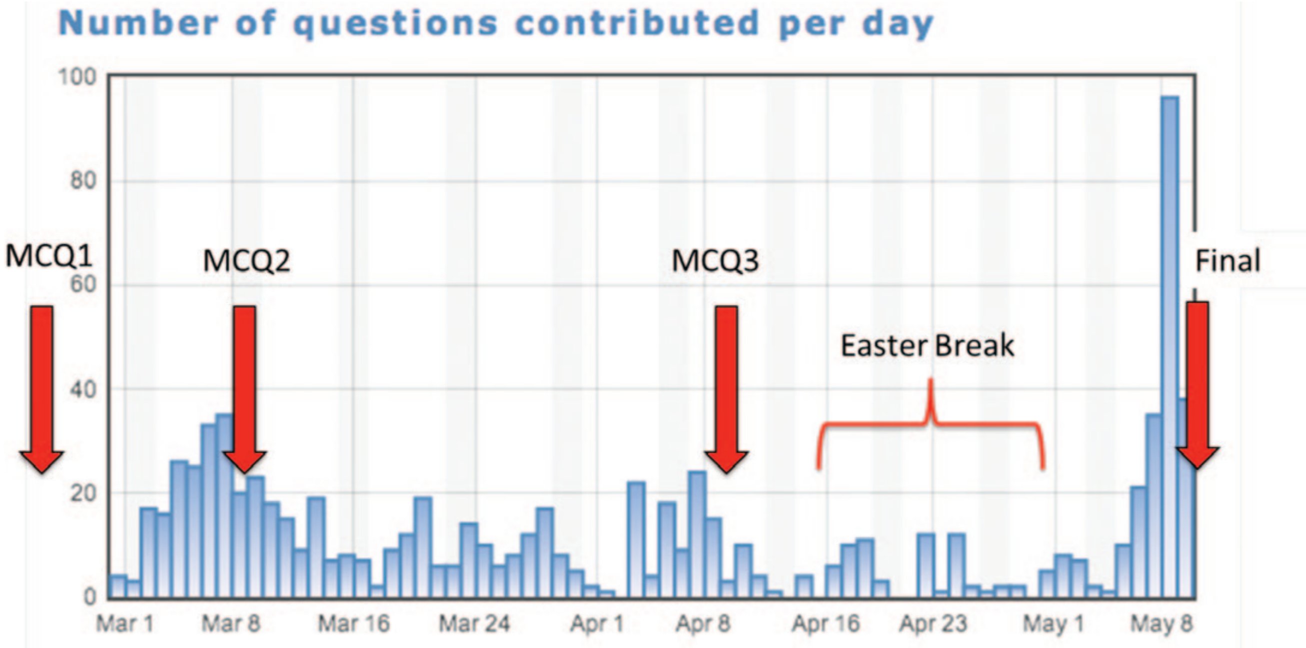

Figure 5.5: PeerWise activity showing the peaks in questions contributed coinciding with MCQ dates

On the whole students did not seem to access PeerWise primarily on their mobile device, although a large number still did, approximately 80 students, shown in Figure 5.6. Some students mentioned in the free text responses that the site is not mobile friendly and would recommend a mobile site to accompany the main site.

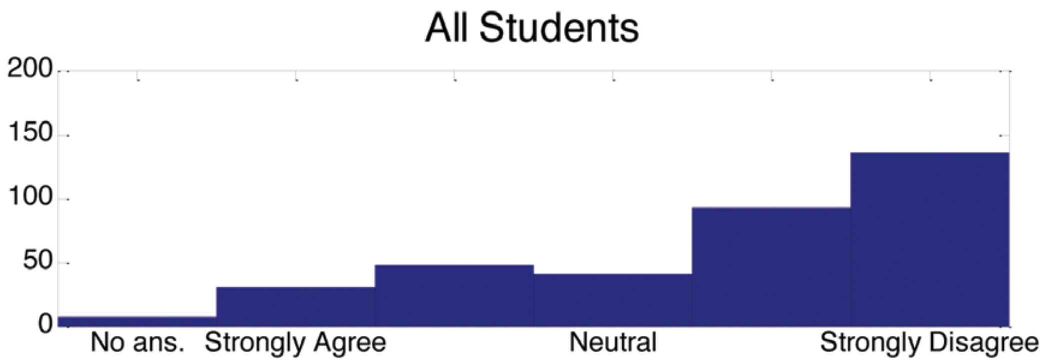

Figure 5.7: Student responses to Question 7

When asked if the students would like to see PeerWise introduced in other modules the spread of answers for the different class groups varied as shown in Figure 5.7. The classes with lower level students, Groups 3 and 4 (Table 5.1) agreed/strongly agreed while the higher academic level students, the second year level 8 students, Group 5 disagreed/strongly disagreed. The first year level 8 student groups which sit, in academic levels, between the two opposing groups responded neutral. This is reflected in the PeerWise activity data where the groups that would like to see PeerWise introduced in other modules were also one of the most active groups amongst the study.

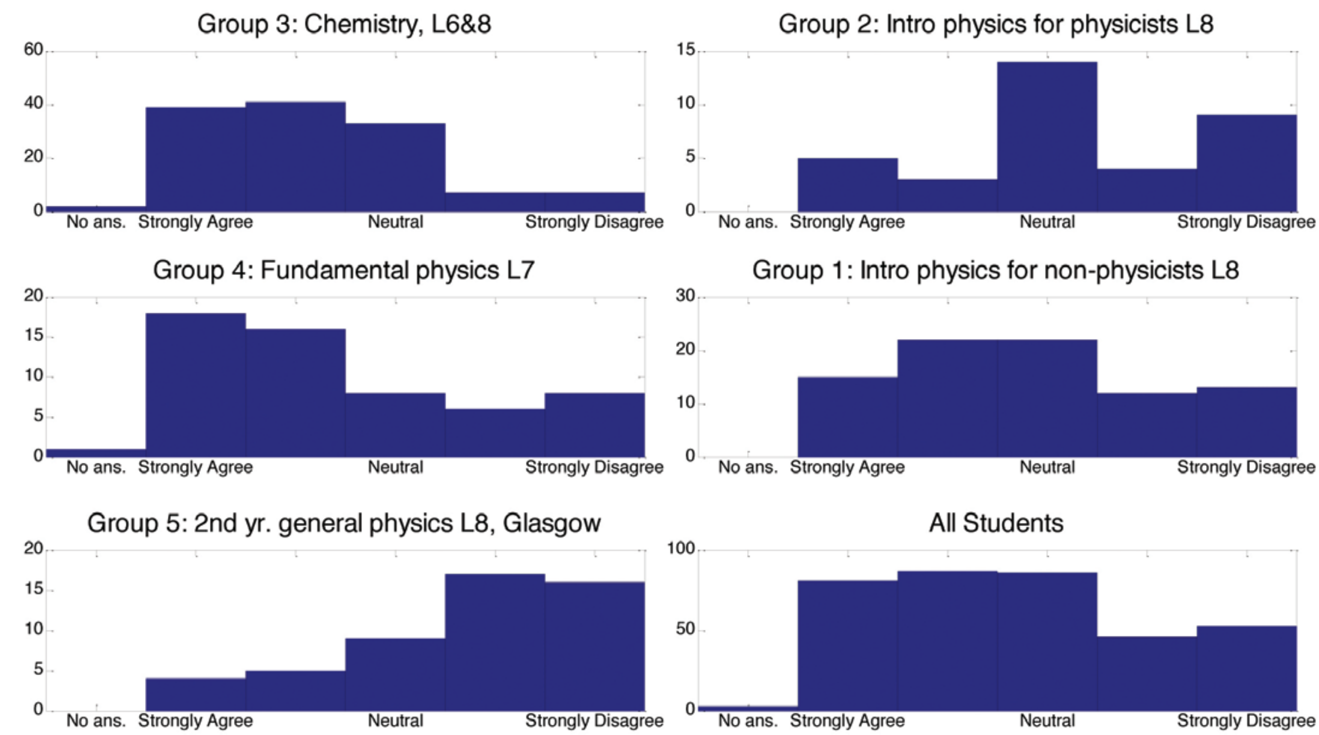

Figure 5.7: Student responses to Question 7

Conclusions and Future Work

Results from the questionnaire suggest that all the students find PeerWise useful and recognise the benefit of authoring and answering questions set by their peers. The students agree most strongly that they would or did use PeerWise for revision purposes.

Unfortunately a correlation between PeerWise activity and an increase in exam mark is not shown for all modules but does appear strongly in the chemistry module.

Recommendations to DIT

Recommendations are also based on ongoing thematic analysis which is not reported here but, it is hoped, will be published soon. It is recommended that:

- PeerWise be introduced as a method of including peer-instruction in large class groups.
- Lecturers check in the software for flags that students have placed on questions for their attention.
- Lecturers may find it useful to examine PeerWise for questions that students are answering incorrectly and address these issues in class.
- Lecturers may show examples of good questions in class when reminding students that PeerWise is a continual assessment with a sometimes distant deadline. This will help engage the students.
- Care should be taken not to be seen to be too involved with PeerWise as many of the foreseen advantages and student-reported advantages are that this is their own space.
- Lecturers stress the importance of self-regulating the system. If there are mistakes on the system, it is the student's responsibility to correct their classmates. In addition, if they see issues arise with bad behaviour (childish questions, bullying, plagiarism, etc.) then they should flag this.
- Care should be taken when PeerWise is implemented in multiple modules simultaneously. No study was carried out on this aspect and it is unknown if this would have an effect.

Proposed Future Work

This is part of an ongoing study were we shall continue to assess the effect of PeerWise on our students. Results on gains in conceptual understanding linked to PeerWise are being reviewed with the use of concept tests in some of the physics modules. A further, more detailed study on the free text answers provides great insight into the students' attitudes to PeerWise. This report is currently in preparation for publication.

Differences in class grouping in this report suggest a different engagement from students with different academic credentials. Further studies to probe this hypothesis are underway.

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