

Reflections on using student-authored questions to encourage learning in physics

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Introduction

In our previous work (Merchant and McGregor 2005) we outlined preliminary studies into the effectiveness of a teaching method designed to encourage students to pose their own questions as an assignment task. While the questions posed by students provide considerable feedback on their progress, several questions about the technique need to be answered: was the dialogue between students on a level where they were discussing true and accurate science? Apart from the first attempt, was the technique practical to implement for large classes? And finally, can this technique be useful in all years of a program? In this paper we provide a further analysis of the student discussions and how they relate to the questions posed, moreover how they relate to the objectives of the course. We will discuss modifications to the assessment task aimed both to reduce the administrative load in implementing the task and to encourage validation of the student discussions through self-moderation. Finally we propose a model for implementing the technique of student-authored questions at different year levels.

Background

One of the main problems involved in the teaching and learning of physics is the formulation of concepts and their logical application. Faced with a changing student cohort who increasingly have less developed study skills, numerous authors have introduced a variety of techniques including peer instruction (Mazur 1997) and workshop tutorials (Sharma, Millar and Seth 1999) designed to improve interactivity and increase engagement of students with the material.

It is often hard for students to come to terms with the relationship between real physical problems and broader concepts or abstract physical 'laws'. Students are not practiced in following the logical constructs from their precepts and resort to the surface-learning or 'Plug and Chug' of numbers into memorised formulas (Biggs 2003), and students are aware of this: 'I always imagined the 'archetypical' physicist to be a person who was creative, imaginative and exciting, rather than someone who just plugs in numbers into formulae.' and '[writing questions] triggers a curiosity which tends to be annihilated in [an] academic system' (student comments). With the majority of assessment in exams, there is unfortunately not a lot to dissuade the student from a path of surface learning (Ramsden 1992).

In this paper, only results from the second-year course of ~50 students will be presented, although a model for the implementation over years 1, 2 and 3 of a physics program (year 1 only for service physics) will be discussed.

Method

The students in the class were divided randomly into groups of four for the purpose of two assessment tasks. In the first task, each student was asked to generate a multiple-choice question in one of three areas relevant to the course: Newtonian Mechanics, Inertial and Non-inertial Reference Frames and Simple and Damped Harmonic Motion. Their fellow students were asked to provide feedback to their group members on each question, and the author of the question would then provide



possible answers including distracter. Students would then provide final feedback on the question, answers and detractors before final submission. Selections of these questions were then used in an assessment for the whole class. The second task was a group task with each group of students asked to write an examination question for use in the end-of-semester examination.

Timeline for each assessment

The assessment was broken down into five steps with assessment weighting attached: initial submission of question idea, feedback from group, question and solution submitted, feedback from group and final question and answer submitted for marking. This timeline was used to motivate students and provide a structure for the entire assessment avoiding where possible a last-minute rush. The second assessment task had a similar, though shorter timeline.

Results

The students participated well in the first task with the class generating more than 300 postings with an average of above 5 postings per student, each of average 120 words within the concept areas as defined by the task (See Table 1). Questions in the area of non-inertial reference frames were slightly favoured over harmonic motion and problems in Newtonian Mechanics. The second task was not discussed to the same extent, and the exam question tended to be written by one or two students in each group.

Many of the discussions followed a ‘loop’ similar to the one shown in Figure 1 in which a student who agreed with the question and answer replied positively and moved on to other discussions. Students who disagreed with the solution offered by the moderator then related previous attempts at understanding the concept. The student moderator would then de-construct the question pointing out definitions and/or assumptions made in the question, the student then refines their line of enquiry and rejects their previous conceptualisation or continues to disagree and the loop cycles once more.

The discussions in the small groups were a rich discourse which typically involved a repeat of several cycles on different aspects of the concepts. For example, the Coriolis Force discussions were interesting because several students were questioning what it was about objects that caused the Coriolis Force to act – for example was it a property of water.

Table 1. Conceptual areas in students questions.

Topic areas chosen by students	
Non-inertial Reference Frames	
- Centrifugal and Coriolis Forces	11
- Inertia	2
Harmonic Motion	11
Generic Problem (no topic)	5
Forces/Friction/Drag/Kinematics	7
Polar Coordinates	
- Central Forces	4
- Transformations	3

There are several benefits to this interaction: encouragement for students to engage with their own learning; a rich group interaction; a peer-to-peer discussion on a concept and, perhaps most importantly, each student has explained why they believe a particular answer to a question is right or wrong.

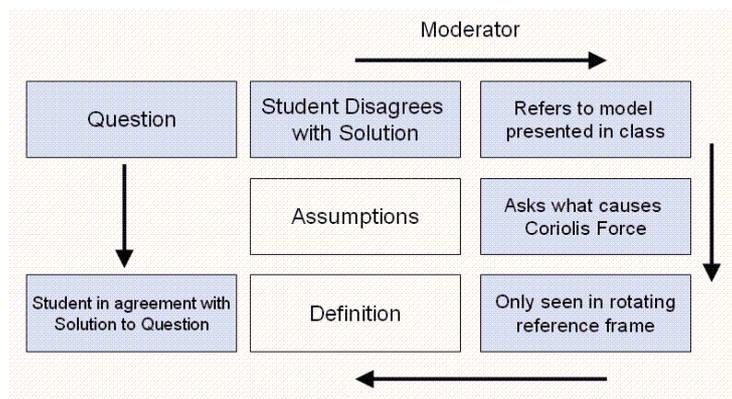


Figure 1. A diagram of the discussion cycle used in resolving issues between student and moderator/ group members. This example refers to a question on the Coriolis Force (a fictitious force in rotating reference frames).

Response to concerns about quality of student dialogue

At first glance this concern is supported by the evidence as the number of references to written material was limited: only 12 of the questions used an equation presented in the learning material, and only 6 discussions included a specific reference to a page and chapter in the prescribed textbook. However, there is also evidence to suggest that the students were reading from the textbook and lecture material before replying or responding: as one student stated ‘your question had me going back to the textbook’. Also, no part of the assessment instructions requested them to cite or reference material.

In all there were 13 questions submitted where the discussion had not identified a better question or the question/answer had a conceptual error. Rather than viewed as a negative, however, it is important to see this as an opportunity to influence the student’s learning. The individual feedback does introduce a significant time penalty, rather than checking a student’s solution to a set problem you are comparing a solution to a student selected one, there is no ‘efficiency’ gain for seeing that a student has the problem correct. While the ability to comment fully on a student’s (mis)understanding, it is nevertheless time consuming.

As will be discussed later, it may be useful to ensure students receive more cooperation in a face-to-face group setting. This has been shown to be successful with the Workshop Tutorials in physics (Sharma, Millar and Seth 1999) which also include a hands-on component. Students were not discouraged from discussing the assessment task face-to-face, in fact several times entering class we was asked about the assessment and my views on one aspect or another of a particular problem. The students were asked to assess a fellow student’s question

- When I read this question, is it clear what is being asked?
- Is the language used scientific and accurate?
- Does the question simply require me to recall a single fact (*basic concept*) or does it test the application of that concept?
- Is the answer as given correct?

Concern over whether the students are discussing true and accurate science pre-supposes that students is invalid as it based on the transmission model of learning where the expert provides ‘everything’ the student needs. This is at odds with the student experience of this task: when asked if it should be extended to all years of the program responded with:

... yes because it makes people do research into topics to understand it ...yes, because I’ve learnt how to research ...yes because it requires students to look into new ideas and concepts ... it was good to work through a problem from scratch and work through the questions you yourself ask.



Outcomes of student surveys

When surveyed at the end of semester the students responded positively with an average of 3.4 (where 5 meant strongly agree and 1 meant strongly disagree) for a sample of 27 students. When asked if they think the technique should be extended to other years of the program they responded:

Yes, [it would] develop the people skills and the general sharing of knowledge [it] encourage[s]...yes, because it is a good method of learning about a particular topic ... helps students put questions into a context that they can understand ...yes, because it was fun as well as satisfying curiosity ...[yes] perhaps [just] one at the end of semester covering all work (I prefer an assignment), this was more difficult than I expected... [yes] its good to have different kinds of assignments; but only have a few over the year and never at the same time ...

A more practical implementation

When worded carefully and engaged by a mature student, multiple-choice questions can be useful learning tools as they can tease out the conceptual misunderstandings students have, as shown by the discussion loops. Careful wording is a skill that comes with practice, and it is a surprise to some students how difficult a multiple-choice question can be to write, as one student wrote: ‘you have to know something really well before you can ask questions about it’.

Impact on student load

One of the barriers to introducing any assessment is the time it takes, both for the student and the academic. From the student’s perspective, the assessment load for this course (worth 12.5% of a full-semester load) included topic-by-topic numeric computer exercises (ten tests with an average of five questions), two written assignments and one three-hour final examination. It was considered reasonable to introduce the new tasks with the assessment weighting provided by reducing the value of both the final examination and computer tests.

Outcomes of student surveys

When surveyed at the end of semester (prior to the exam) the students responded positively when asked if ‘assessment for this course tested my knowledge and understanding’ with a mean value of 4.2 on a Likert scale (where 5 meant strongly agree and 1 meant strongly disagree). The students also responded positively when asked if ‘the assessment load for the course was reasonable’ with an average of 3.5, whether ‘writing student-authored questions deepened their understanding of concepts’ with an average of 4.0. The same group of students responded positively to ‘the computerised tests questioned their understanding of concepts’ with an average of 4.2. Finally, when asked if ‘the small group project challenged my understanding of physics concepts’ the average response was only 3.4, but this is reasonable as students were asked to choose a topic which challenged them.

Administrative load - implementation in *Blackboard*

This project was implemented on *Blackboard* v5.5, a mostly GUI driven system available to all students in the class on or off campus. To begin this project required several steps per student: creation of groups, addition of students to groups and creation of discussion boards (individual by student). For the implementation of *Blackboard* at RMIT, there is no automated group creation function, so as a rough guide: start-up is about 1 minute (login, authentication, select course and open class *Blackboard*), then for each group creation took about another 2-3 minutes and 10 mouse clicks (not including typing of student names). Each student added to a group was another 6-10 mouse clicks again not including typing. Each discussion board required another 4-5 mouse clicks (each student moderated their own board with administration rights). Therefore before the task begins, a class of 50 students sorted into 12 groups and established in *Blackboard* translates to ~1000 mouse clicks not allowing for any errors or changes to groups due to withdrawal etc. Following the

submission of the task(s) we downloaded each and every discussion board posting and pasted them into *Microsoft Word*. This took again several hours spread over days as there was no function available to download the contents of each student's discussion board. For the second assessment task we asked the students to submit a copy of their discussions and this would be an easy modification to the original task which would reduce the administration.

The role of technology in implementation

Using the existing implementation of *Blackboard* at RMIT, the project is time consuming to setup, administer and then analyse the data for a class of ~50 students. By simply changing the assessment to ask students submit their discussions with their question represents a significant gain in efficiency. We envisage that with planning it would be possible to run this on the existing system with up to 100 students.

To move beyond this number of students, one solution is to write a computer package which assists in the administration: allocation of groups, batch creation of discussion boards, facilitate peer assessment (where required) and provide a student-by-student marking procedure. At RMIT most of this functionality could be implemented within *WebLearn* (a proprietary web-based computer testing facility) and certainly peer-assessment and marking interface would be a useful functionality within any computerised testing package.

Implementation at different year levels

For our physics program this assessment task addresses specific graduate capabilities of our students. *Knowledge*: exhibit proficiency in accessing information from a variety of sources; *Critical analysis and problem solving*: able to creatively and critically analyse a body of knowledge and data for logical consistency and unifying or anomalous features; and *Communication*: able to critically review the work of others.

Implementation for first-year

From the experience of running the project for first-year service students it is clear the exercise of writing the questions and answers was very different from the assessment tasks they had performed previously. A more structured assessment task, for example re-writing a poorly phrased multiple-choice question before asking the students to embark on creating a multiple-choice question is more appropriate. From our perspective, the skill of dissecting a sample conceptual question is valuable as an exercise if outcome is an improved interaction with our existing computerised multiple-choice tests.

Implementation for second-year

In its current form, the assessment task is most appropriate for a second-year course. The task as presented was aimed at more active involvement by students in the design and usage of such forms of questioning. It asks students to consider their learning process more directly by assessing them on their ability within a group to devise their own questions. It is predicated on the belief that the best questions students have are those that they pose themselves. Our method may need to be offered more than once per semester to ensure the students understand the process, and appreciate this as a valid learning experience. The existing model should benefit by requesting students reference textbook or lecture material (where appropriate).

Implementation for third-year

For a third-year group the project could be incorporated into research methods or (if available) a research project, with the group component focussing on the extraction of a key idea or theory (what questions are being answered in this paper?) from a given journal paper or papers and presentation to peers.



Conclusion

An innovative assessment task involving students authoring their own questions was successfully implemented in a second-year class. The discussions of the students followed a loop which showed the students were examining assumptions and reflecting on their understanding of concepts. The technique was practical to administer with the existing implementation of Blackboard but probably only manageable with up to 100 students. Concerns regarding the validity of the discussion can be ameliorated by asking students to cite sources of information where appropriate. Minor modifications to the assessment at first-year level include a more structured assessment with a task focussed on improving an existing question before asking the students to write their own. At the second-year level, the changes include asking students to submit a log of group discussion with their written questions in electronic form and asking students to cite references. At the third-year level, a similar task can be incorporated into research methods or a science project with the focus on journal articles or similar published material.

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