[O19] Student authored questions encouraging a deeper learning in physics

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INTRODUCTION

In this study, we started with the assumption that the best questions are those that students pose themselves. We would like our students to be continually asking themselves questions about the material, but the confines of the class often limit this enquiry to a common syllabus and to questions set by the teacher, not by the student. Any subject does need to be clearly defined, but a danger with an over-defined course is that self-enquiry is not encouraged and that student experience can be curtailed. Particularly in the early years, students are seldom given the freedom or encouragement to think about their own questions, or to think about the value of asking their own questions. A lack of independence in studying is characteristic of a shallow approach to learning (1).

When worded carefully and engaged by a mature student, multiple choice questions can be a superior learning tool as they can tease out the conceptual misunderstandings students have. However, less-mature students tend to overlook the benefits available in multiple choice questions and look only for the quickest path to the 'right' answer. A way around this, as shown by Mazur (2), is to use ConcepTests in the tutorial/lecture environment to create an opportunity for students to choose an answer and then convince each-other of whether one answer among many is correct. The dialogue created by this exchange is a form of peer learning and leads to deeper understanding of concepts (2).

This study was aimed at more active involvement by students in the design and usage of such forms of questioning. We used peer interaction to encourage questioning of novel problems. It was considered that working in groups on novel problems, less experienced students would be able to interact with more experienced programs to refine their questions. If the problem was rich enough, then the group of students would be able to come up with a range of answers. If students got into the spirit of the game, they would be able to come up with a range of answers that would be enough to baffle a group of their peers, but which would still allow the correct answer to be found. This games theory aspect to their learning might increase the students' motivation.

METHOD

In 2004, we undertook a project to investigate the ability of students to follow through on their own questions. This involved two cohorts of student; a first year engineering class studying electricity as a service physics subject, and a second year class for Physics majors. The latter was an intermediate level course involving advanced Mechanics (including non-inertial reference frames) and Lagrangian Mechanics.

As an assignment, students were asked to devise their own questions and come up with suitable answers. The format chosen was multiple-choice and each student had to formulate their own question and suggest an answer. Working in small groups, their peers would then consider the question and propose their own answers. If all the students arrived at the same answer, then it was suggested the question was too easy and that it should be reconsidered. If it was too 'difficult', such that students felt they could not adequately answer the question, then it was suggested that the question should be clarified or simplified.

Students were asked to use the on-line discussion capability in BlackBoard so that we could monitor the process undertaken by the students. Students were given a week to devise their question and a further week to discuss the other questions in the group.

Significant time was devoted in class in setting the ground work for this assignment with the students, as none had undertaken a similar form of assessment. The importance of this exercise in promoting self-directed study was stressed. Students were encouraged to think about where they were at in their understanding of the subject material and to then probe beyond that point.

The importance of thoughtful posing of questions as well as of the creation of credible detractors was talked about. We stressed the need for questions which teased out some aspect of the underlying concepts, rather than ones which required simply the correct substitution of numbers into a given formula.

Consideration was also to be given to the clarity of the questions; they should be concise and should not contain large amounts of unnecessary detail or red herrings.

MONITORING PROGRESS

We were able to read the students' postings on Blackboard but did not interfere in their progress. At the end of the period, we marked their assignments according to the criteria discussed with students in the preparatory period. As well as the quality of the final questions and answers in the final assignment, we took into account student's input and involvement in the on-line discussions.

We took the best of the students' questions and answers and used them in a Weblearn test given to the whole class. Weblearn is multiple-choice on-line testing facility.

ANALYSIS OF QUESTIONS

We analysed the type of questions that were put forward, the pertinence of the detractors as well as the explanations that students proposed for the answers.

The quality of the problems and answers was measured by both the complexity of the concept underlying the question and by the degree of effort required to arrive at the correct answer. This can be shown, for example, in the question written by a Physics student:

A person is riding a merry go round travelling at a constant speed. He is seated on the outermost seats, of the circle. As he is going around, he decides to throw a tennis ball he is carrying. As he observes, the ball appears to be travelling outwards, but as the ride is turning, the ball also appears to be falling behind his line of sight. From the rotating frame of this person (this is) due to which force or forces:

A. Centripetal Force.
B. Inertia.
C. Centrifugal Force.
D. Coriolis Force.
E. Both Centrifugal and Coriolis Forces

This is a good quality question as it delves beneath the simple recall of what the three non-inertial forces are and seeks an explanation of what is happening. The detractor answer of 'Inertia' has the correct physical meaning but due to the way the question is asked it is not the correct answer.

We categorised the questions and answers roughly according to whether they were:

- deep or shallow; Did the question ask for a simple recall of the concept?
- abstract or real; Did the question relate to a real situation?
- numeric or conceptual. Did the question involve a calculation?

These are not mutually exclusive attributes but define a continuum with most questions falling somewhere between the two extremes. The attributes of questions had been discussed with students in the preparatory period.

For the both groups, the ratios within each classification were as follows:

	First year engineering group	**Second Year Physics group**
Deep/Shallow	1.4:1	1:1
Abstract/Real:	1.7:1	1:1
Numerical/ Conceptual:	2.2:1	1:2

Although students were asked to think primarily of testing concepts through their questions, many in this engineering cohort still chose problems whose solution primarily required a numerical approach. Many of the detractors were variants on the numeric answer such as due to simple transcription errors, without involving different conceptual mistakes.

In the first year cohort, the majority of questions were more abstract, in the sense of problems not being strongly applied to realistic situations. This mix of results does accord with students thinking of variants of text-book problems. It might be argued that first year level electricity has fewer novel concepts than those in a second year level mechanics course and that students might see more opportunities for numeric type problems. However both areas are rich in conceptual problems.

In general, the second year discussions were demonstrably deeper. The involvement described answering each-other's questions, identifying misunderstandings and explaining concepts. For example, students in the second year class commented 'Just because I wrote the question doesn't mean my answer is correct', 'If you could post the answer that would be sweet . . . I'd like to know if I got it right', '(your question) had me going to the text book' and 'I think I got caught in my own trap'. Overall the timbre of comments was very positive and constructive in both groups.

The use of a discussion board for group interaction was new to both groups of students However most in the first year group (80%) participated and 80% of those did more than one posting (average of 5 per individual discussion board) while in the second year group 90% participated and 96% did more than one posting.

FOCUS GROUPS

At the end of semester, the first year Engineering group was invited to attend a focus group to discuss the experience. There was a mixed response from students; from those who could appreciate the purpose behind the assignment, to those who thought 'there was not much point and didn't really like it'.

The most relevant questions that were asked are given below along with some of the more telling, informative responses.

1. What did you think was the objective of the 'question writing' activity?

a. It forced us to study more and understand the material in order to set the question and its answer;

b. Helps determine where we are having difficulty and so helps with exam prep;

c. Helps understand MCQs better, especially detractors – this helps for exam prep;

d. To try and find the hardest possible physics question and then answer it;

e. So Ken wouldn't have to write questions.

As answer d suggests, it is difficult to guide the student to the level of difficulty that should be attempted. Being able to come up with a question which has the right degree of complexity yet is 'manageable' by students in the class, is difficult for the teacher, far more so for a student learning the subject for the first time.

For those that were not enthused about the assignment, the cynical answer, e, may have been quite genuine.

2. What did you learn about physics?

a. It's not all calculation based;

b. Didn't help understand physics because in physics everything is related and one question can't help out on the whole thing.

Answer b was somewhat unexpected. Although each student was asked to devise just one question, they were in groups of four or five students whose questions the student was also asked to address.

3. What did you learn about writing questions?

a. Didn't really write the question. I took it from a book;

b. It's hard;

c. Learnt how to trick and deceive using MCQs;

d. Physics is stupid and fun and useful;

e. How much understanding you need to write a question.

The answer, a, is obviously an 'easy' way out for student. Although some questions seemed very similar to those found in text books, it is impossible to always tell which question has been truly devised by the student. However most appeared to be genuine efforts at devising question that they wanted to address and that were novel to them.

If the respondent at c has learnt to analyse questions more thoroughly, then it was a useful exercise. Hopefully, the physics understanding of respondent for e has also improved.

4. What did you like about the activity?

a. Freedom and choice of what we could do;

b. Easy marks, better than doing a test;

c. Feedback from group members helped improve your question and so get better marks;

d. Activity is stupid yet satisfying;

e. Self interest, challenging;

f. Had to do some physics;

g. Straight forward assessment task.

Although the method of formulating and discussing the problem was laid out, there was almost no restriction of the question they could pose, provided it kept within the broad topic bounds.

5. What did you have difficulty with in the activity?

a. The activity was a burden;

b. Boring, don't like electrical systems;

c. Working with people I don't like;

d. Finding a concept to apply to questions.

Answers a through c are responses that may be found for any task. However, it is definitely not easy to think of a question in a new field which has just the right degree of difficulty; that helps in the learning process, rather than being 'a bridge too far.' Half the difficulty in learning is properly assessing that which you don't know.

One aspect not discussed in the focus group, was the cultural and language background of the students. There were a small but significant number of students in the engineering class for whom English was not their main language and who had some difficulty in expressing themselves in non-mathematical English ways. They were less confident in putting their ideas forward in common group work. Such students were more likely to have experienced more traditional, structured teaching in physics.

This trial was a single event as far as the students were concerned; an assignment which was novel for them but which was not part of an ongoing method applied to their learning experiences in the course or program. In that regard, it might be expected to have only limited results in changing the learning style of students and indeed there was no significant correlation to be found between the quality of the question posed by individual students and the mark that student subsequently obtained in the Weblearn test.

This particular method of asking students to generate their own questions could become a useful adjunct to the suite of learning activities proffered to students, but it would have to be modified to be more practical. The degree of monitoring of student progress was too time-consuming and this would have to be reduced. In addition, assignments involving the generation of questions would have to be done on a regular basis so that, for students, it became an established normal method. For students involved in this isolated trial, there was no further reinforcement of the method.

CONCLUSIONS

The study has been a useful exercise in determining the response of students to being so openly challenged with the creation of their own questions and detractors. It provided a rich group interaction and got students to articulate a question which they believed was interesting or important to their area of study. Each student came to terms with why they believe a particular answer to a question was right or wrong.

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