An Active-learning Approach in Teaching Physics 007

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ABSTRACT

We discuss in this paper our experience of introducing active learning approaches in teaching a general education course PHYS007 Physical Phenomena in Everyday Life for non-physics majors. We shall discuss the approach we took, the difficulties we faced, the feedback from students, and the experiences we have drawn from this education experiment.

A BRIEF DESCRIPTION OF THE COURSE

I believe it is our common experience that a typical HKUST student has the following characteristics: rather smart, good at memorizing "fast-food" type knowledge but reluctant to go deeper into understanding what lies behind it. They are used to accepting "standard answers" in textbooks, but are weak at building up knowledge from experiments or from critical thinking. It is probably not surprising to learn that our secondary school students are getting worse in learning science compared with other countries. In particular our students' overall attitude towards learning science is found to be poor compared with other advanced countries [a].

The course PHYS007, "Physical Phenomena in Everyday Life", which I started teaching two years ago, is a response to the above situation. PHYS007 is a Physics General Education course for non-physics majors. In developing this course, the question of how one can 'teach' our students the correct attitude towards learning science always occupy my mind. I noticed that many of the basic materials I cover in the course, including force, Newton's Law, and Electromagnetism, are being taught in secondary schools in a fragmented way where the "road map" of how these subjects are built up is erased. Without an appreciation of these struggles, science seems totally inhuman and isolated from our daily life. In my course I try to put back these features by asking 'strange' and sometimes 'stupid' questions which scientists have often asked themselves in the course of building up their knowledge. In this article we shall describe two instructional approaches we adopted in the course: Active Learning and Problem-based Learning.

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[a] **TIMSS-R** (The Trends in International Mathematics and Science Study) **data**

Active Learning

Active Learning (AL) is not a new approach. We all use AL sometime or another in our teaching without realizing it. AL involves putting students in situations where they have to do the thinking and learning by themselves. In other words, AL puts the responsibility of learning in the hands of the learners. To implement AL into our course, we constructed a set of questions for each lecture and strategically placed them in our lecture notes where parts or sections of relevant notes are deliberately left out. These questions are usually designed to enable the students to go beyond the textbook to stimulate their thinking. The questions are usually structured to depart from ordinary textbook-type questions and may or may not have definite answers. For example: *How do you know that the electric charge coming from rubbing a plastic rod is the same as the electric charge running in our electric circuit? Do you think the existence of a universal set of physics laws fundamentally contradicts the existence of "free will"? What would happen if Newton's third law is violated slightly? How about the first and second laws?*

Problem-based Learning

This is not to be confused with project-based learning, even thought they both share the same acronym, *PBL*. In project-based learning, students are usually assigned a problem with a given end product in mind (Blumenfeld, P C et al, 1991). In Problem-based Learning, however, the students are given a problem to solve or learn more about. The problems are usually structured in such a way as to resemble real-life problems, i.e., *complex, open-ended and ill-structured.* The main difference between problem-based and project-based learning is that former may or may have any product at the end of the day (Duch, B, 1995) & (Hoffman, B and Ritchie, D, 1997). In Problem-based Learning the instructor's role is as facilitator or coach.

To implement *PBL* into a course and to give the students a feeling of how scientists work, each group of students is given a problem to solve. The size of the group is usually about five students. The nature of the problem is specifically designed to depart from normal textbook problems. For example: Measure the length of a pencil that is shorter than 12 inches with a one-foot ruler with no finer calibration. Can you show that the velocity of an object is not proportional to the force applied to it (which was believed to be true before Newton)? Give three examples of chaos in economical or environmental phenomena, etc. Each group is asked to solve the problem in any way they want.

With *PBL*, I hope I can encourage students to change the habit of looking for "correct answers" in textbooks, and to have a feeling of how knowledge is built up from experiments and critical thinking. At the end of the semester, I also gave the students the choice of taking a written (multiple choice) examination, or writing a paper analyzing a problem of their choice using a scientific approach.

STUDENTS' RESPONSES

The course evaluations in the last two semesters indicated that the students' responses to the course are mixed. There are students who welcomed and highly recommended the course to their classmates. There are also students who think that the course is simply badly organized and a waste of time. A detailed analysis of why students like or dislike the course has not been made, and I can only report here my own feeling or experiences.

First of all, let me note that the responses from students in Spring 2000 (the first time the course was offered) showed that the course was quite successful. I have over 100 students and yet the teaching evaluation showed that a large percentage of the students welcomed this course. This rather unexpected success encouraged me to admit more students and try something more complicated in the Spring 2001 class without planning carefully. As a result the teaching evaluation dropped considerably in Spring 2000. *The new ingredient I put into the course (basically asking the students to solve a problem they have not seen before) is too difficult for the students and the class size just exceeded the maximum capacity one can handle with the way the course is organized.*

Aside from this technical mistake the major difficulty I faced is that many students do not appreciate a course that spends lots of time talking about things they seem to have learned before and yet does not provide clear answers to their homework. Nothing seems to be "solid" as in a normal science course where every question seems to have a "correct" answer. This is, of course, the fundamental problem of learning habit and is where I have started. However, in its present form, it seems that PHYS007 is welcomed only by students who are already unsatisfied with the old way of teaching and are ready to welcome a more active-learning approach. So far the course has not been too successful in stimulating the more average students.

This semester the course is offered to secondary school students via the CyberU project organized by Dr. T.C. Poon. Note that there is no pressure for the students to take the course. The responses from the students are good so far, consistent with our experience that the course is welcomed by students who are more motivated towards active learning[b].

SUMMARY

Finally let me summarize my experiences in creating an active-learning course. First of all, in view of the rapidly changing school environment in Hong Kong, I think that more active-learning courses should be created. In the school sector, the number of voices asking for active teaching approaches has been increasing. However, a strong and broad knowledge background is needed for teachers teaching this kind of course, and the requirement is not satisfied in general. The Curriculum Development Institute has been interested in offering PHYS007 to secondary school teachers because this may stimulate teachers to use active learning approaches in school.

[b] For example, in a project asking students to measure the volume of any object they chose, one group of students decides to measure the volume of the **Hong Kong Space Museum**, and came up with a rather reasonable result. In another project where students are asked to survey the opinion of the general public on what is "science", the students have done a survey within their schools with interesting results showing clearly some of the common misconceptions about science among the general public. These misconceptions are common even among schoolteachers.

Although the response of the students to this course is in general positive, and I was very impressed by the originality and the hard work some of the students showed in their projects[b] or papers[c] , the difficulty in teaching courses of this kind should not be underestimated. Most of our students are used to following well-defined guidelines in learning and have no prior experience of learning without a given guideline. As a result, most students welcomed active learning methods only if they do not occupy too much of the course. This situation will last for several more years before we can see any significant change in the attitude of our incoming students. Offering *complete* active learning courses to our students may not be the best way of teaching at this moment, and is certainly not the best way to get a Teaching Award, at least in the near future.

REFERENCES

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[c] Examples of interesting final papers include: a paper analyzing the outcome of the mark-six lottery; a paper analyzing why beauty is so important for earth's female humans – from the viewpoint of an alien who has visited earth for 12 years; a paper analyzing US immigration policy (written by an exchange student), and many others.