

A rethink of the reform of the *University Physics* course in Harbin Engineering University

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Abstract

This paper is a rethink of the reform undertaken in the *University Physics* course after ten years of reform work in accordance with contemporary education theory. What we have done and how to improve the reform are discussed. It is very important to transfer from teaching-centred strategies to learning-centred strategies.

Introduction

In Harbin Engineering University (HEU), *University Physics* is a basic course but also a service course for all first-year students majoring in science, engineering and economics. The content of the course includes classical mechanics, rotation of rigid bodies, thermodynamics, electrostatics, magnetism, mechanical vibrations and waves, physical optics and modern physics. Modern physics includes special relativity, quantum mechanics, solid state physics, nuclear and atomic physics. According to the syllabus made by the Ministry of Education of the People's Republic of China, the course is compulsory. It is based on the concept that physics is the foundation of all sciences and engineering. As well as being concerned with deep fundamental questions, physics forms the basis of most present and future technology. The *University Physics* course is the core course of university science education in the 21st Century for those who will study or apply science and technology in their lives and future work.

The course is arranged in two successive semesters in HEU. There are 112 hours of lectures and 64 hours of experiments in the laboratory. Every year, around 4,000 students enrol in the course. They are divided into 25 large classes for lectures with 15 lecturers all covering the same content. Homework is assigned weekly. There is only one common final examination in each semester.

The current teaching method used in the *University Physics* course in HEU is the 'lecture'. It is a teacher-centred strategy. The lecturer shares her/his information with hundreds of students who take notes and have little opportunity to communicate with their lecturer during class. The students are passive and have to learn what the lecturer prepares. We arrange a schedule of times for answering students' questions, but they mostly were not available at that time.

What have we achieved?

About ten years ago, we found that students had little interest in learning physics. They thought it was hard to learn and understand because they hadn't learned enough calculus to cope with the *University Physics* course. They found it difficult and boring to learn from a lecturer with no demonstrations about the processes of physics. The textbooks emphasise concepts, laws, theories and logic in physics and are rarely related to real-world problems which surround them in everyday life. Students cannot develop the ability to apply the processes of physics to solve science and engineering issues.

As a result, we reformed the *University Physics* course in the following ways (Zhao, Sun and Ma 2001).

- Changing the timing so that the *University Physics* course begins later in the semester than the *Advanced Mathematics* course. This guarantees students should have enough mathematics knowledge for their physics learning.
- Revising the textbook ourselves with new content according to our situation, closely relating it to contemporary science and engineering research and application. The new textbook was published in China in 2001.

- Using *PowerPoint* to give the lectures. It is clear and colourful. More information could be shared, so students have more interest.
- Building up the demonstration laboratory, which is about 160 square metres and includes 80 demonstration experiments. Students are permitted to experiment by themselves. We also built up four creative laboratories in which students could do some self-designed experiments related to their learning.
- Utilised multimedia such as video and computer software to demonstration and simulation. Multimedia is good at demonstrating the very fast or micro-world processes of physics. It is convenient for the lecturer to explain the truth in the processes of physics.
- Loading assignments, detailed solutions and some courseware such as 'Study Guide to University Physics' and 'History of Physics' on university intranets. It is convenient for students to check and get help at any time.

All the above have been positive and significantly improved teaching efficiency. Students have more motivation to learn physics and gained better results.

Why and how to improve the reform?

However, in consideration of contemporary education theories, these reforms have not been enough because the teaching methods themselves have not been improved. Teacher-centred strategies remain, particularly in lectures. I have learned many contemporary teaching strategies (King 2004) at The University of Sydney, which relate to behaviourist theory, development theory, constructivist theory, problem based learning (PBL), case study, concept mapping, and use of the Web. I have also gained knowledge of what has been done in the School of Physics at The University of Sydney. Comparing with these, I suggest some modifications that would make our course more student-centred. The modifications would focus on transferring teacher-centred strategies to student-centred strategies. This is vital and necessary to improve the reform in HEU and achieve more quality teaching and learning.

Introduce PBL to lectures

PBL (Illinois Mathematics and Science Academy 2001) is a learning environment in which learning is driven by a posed problem in which the learner is interested in solving. The problems are based on real-life, open-ended situations because teaching and learning in science should be made more relevant to the life of the students and as close as possible to a real professional experience (King 2004). Learning is active, integrated, cumulative and connected. PBL is a specific strategy for engaging students in collaborative learning, critical thinking, improving their problem solving skills and lifelong learning skills. It is helpful for students to combine the knowledge of different disciplines, which can open the students' mind. There are many questions about physics that are around us in everyday life. Most of them are suitable for the lecture. For example, why is the sky blue? If students find that the more answers they discover, the more questions they want to ask, then they are 'on the road' to becoming a physicist.

Introduce 'Workshop Tutorials' to HEU

The 'Workshop Tutorial' (Sharma, Millar and Seth 1999; Sharma, Wilson and Millar 2001) is a supplementing method that can promote a deeper-level processing of learning. As we know, the quality teaching should be aimed at promoting deep-level processing of information in the mind of the learner. It is a successful teaching and learning initiative. The 'Workshop Tutorials' are valuable. Firstly, they provide a learning environment with significantly more student control and choice. Secondly, they provide a variety in the available learning styles such that students with different learning styles can be accommodated.

There are computer aided instruction systems, demonstration equipment, references and tutors in this environment. The role of the tutor is to support by asking questions rather than by simply giving answers. The designed materials are used to promote discussion and conceptual understanding. Structured worksheets (Sharma, Wilson and Millar 2001) with a variety of activities are designed for students. Students have the freedom to choose activities and time for each activity but they are focused on teamwork through the use of team answer sheets. Students in the 'Workshop Tutorials' work in cooperative teams of three to five, reading, discussing with teammates or tutors, drawing, doing experiments, articulating and presenting logical arguments. Each member of a team is responsible for both learning what is discussed and helping other members learn, thus creating an atmosphere of group achievement. Students use different ways to get information. This helps students to open their minds. They obtain a deeper understanding of concepts in physics and develop the students' skill such as self-directed skills, research skills, communication skills, critical thinking skills and teamwork skills. What is more important is that students understand why the required 'skills' are important within the discipline, rather than just knowing how to use the skills.

The following are some comments by students in a qualitative survey following 'Workshop Tutorials' (Sharma, Wilson and Millar 2001):

1. 'Asking questions about the demonstrations really helped me clear up some concepts that I didn't understand properly';
2. 'Getting to know people and discussing solutions'; and
3. 'The atmosphere is good. It's relaxed and help is always available. It makes it easier to figure out the physics without any stress.'

Introduce the Personal Response System (PRS) to lectures

Interaction in the lecture is very important. It dictates what the lecture focuses on and how to process the lecture. The easy interaction in physics is through demonstration but it is not very effective in informing the lecturer and students about what and how their classmates think. When the lecturer asks a question in the class, the students do not answer the question because some are shy and some do not like to show their stupidity if they make an incorrect answer.

PRS is an effective and powerful interactive classroom communication system in large lecture classes for giving instant feedback to the class (Sharma, Khachan, Chan, Stewart, Hogg and O'Byrne 2002). With PRS, each student can answer the question by pressing a number on a keypad. The responses are collected by a receiver, processed by a central computer, and displayed to the class in the form of a histogram. The student finds the answer correct or incorrect by an identification number that is only known to them. Displaying the collective responses to the whole class helps improve students' confidence because they become aware that a fraction of the class thinks similarly to them. It also promotes student-student interaction (Samiullah 1995) and this is also important. Also, the lecturer can promote interactivity by assigning one keypad per three students and requesting group responses.

Challenges

While many advantages have been presented above, modifications will bring some challenges for teachers and students. It will take time for other colleagues to understand the contemporary education theory, especially the student-centred strategies. It also will take time and hard work to get their support. For the 'Workshop Tutorials', there are not enough rooms or tutors in our department because of the high number of students enrolling in the *University Physics* course. We should get the support from HEU but I think I could start with the students from within our own department (around 160 students). We could get enough rooms and tutors for these students.

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