Science teaching and learning reconsidered

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Abstract

Based on current teaching ideas and the characteristics of a *University Physics* course, the teaching and learning styles of this course have been reconsidered. The combination of the traditional lectures and contemporary education strategies will be used to make Physics more exciting. A detailed description of how to use case study, concept mapping, and problem based learning (PBL) in *University Physics* teaching will be been discussed.

Introduction

Everyone is a learner – babies learn automatically, without having to be taught. Everyone is also a teacher – a Chinese phrase says 'Two heads are always better than one'. Teaching and learning should be inseparable, in that learning is a criterion and a product of effective teaching. Someone has not taught unless someone else has learned.

Teaching is a great profession. A teacher is regarded as an engineer of the soul of human beings. Our subsequent lives are often directly assisted by teachers and teaching aids, that enables us to develop and adapt to the world around us. I am proud of being a teacher, especially being a professor teaching physics in a university.

Physics is about the rules of nature – so beautifully elegant. We can't enjoy a game unless we know its rules, whether it is a ball game or a computer game. Likewise, we can't fully appreciate our surroundings until we understand the rules of nature. I enjoy physics, and my students will too – because they will understand it (Hewitt, 1998). So I always ask the students in my *University Physics* course to 'Please enjoy your physics!' However many of my students think that physics is boring and difficult. Why do they think that? In order to be a good teacher, I have the responsibility to reconsider our science teaching and learning.

During January to June 2005, I was honoured to have the opportunity to participate in a cooperative program for *Teaching Science in English* supported by the China Scholarship Council and The University of Sydney. This program consists of two major components: the first is an intensive English language component with the Centre for English Teaching, and the second is a semester working with the Faculties of Science and Education and Social Work. We had exposure to practical experience with a broad range of teaching and learning situations, including lectures, tutorials, discussion groups, laboratory classes, field excursions and workplace experiences. We were also introduced to teaching and learning strategies and contemporary issues and research in science to help develop independent and lifelong learners (King, 2005), including: problem based learning, case study, student-centred learning practices and online learning strategies. These theories and strategies were taught and delivered by a mixture of lecture-style presentations, seminars, group work, and peer presentation. We rarely use such techniques in the teaching of *University Physics* in China. During my study, I have to reconsider the current situation of our *University Physics* course and I want to find the reasons why the students are not interested in studying physics.

In this paper, the different teaching and learning strategies and their effects are analysed and reconsidered to make *University Physics* more exciting.

Current problems and possible solution

University Physics in Tianjin University is a two-semester course that has five parts: Mechanics; Thermal Dynamics; Waves and Optics; Electromagnetism; and Modern Physics. This course is compulsory for students undertaking an engineering major, and classes usually have over two hundred students.

The current teaching methods are actually teacher-centred. The students seldom interact with their teachers in such a large class.

In the 1960s, science majors including chemistry, mathematics and physics became very popular in China. Actually, learning physics is an excellent way to develop logical thinking, observation and practical skills. But students cannot see the relevance of physics to their future. They prefer computing and electrical engineering, which they see as being more valuable when trying to find a good job.

The possible reason is that they are not involved in both the teaching and learning process. The teacher just gives formal lectures in the traditional way. They seldom used good techniques to improve their teaching quality and never find ways to make physics more exciting. On the other hand, the students can't see the relevance of physics in developing the practical skills they need in the future. They attend class just because they want to pass the examination and get the credit for their graduation certification.

To solve the problem, high-quality lectures are still needed because *University Physics* is a fundamental course and a great deal of basic knowledge must be delivered to the students. Science teaching requires attention to both the content of the course and the process of moving students from their initial state of knowledge and understanding to the desired level. The introduction of one or two innovative approaches to this course will be more effective. I am going to select a small class (less then 50 students) and deliver the course in English as well as in Chinese. I will also use the new teaching strategies such as PBL, team work and workshop tutorials that I learned in the *Teaching Science in English* program. It will be a challenge for me because I need to redesign this course to transform the situation from teacher-centred to student-centred. I think the students will enjoy the changes, because they will find physics more interesting and less difficult. And, in this course, they can improve their English and practice the skills they will need in the future.

Characteristics of good teaching

What is the most effective way to teach students? The answer depends on what students are expected to learn. You cannot teach anybody anything if they do not wish to learn it (King, 2005). Active participation by students helps them construct a better framework from which to generalise their knowledge.

The first step in preparing to teach a course is to decide on a particular style of teaching that is compatible with and appropriate for the students and the goals of the course. It is good to use a combination of the teacher-centred and student-centred teaching styles. Good teaching is much more than grabbing the attention of the students and communicating with them – it involves getting them to think, taking charge of their own learning and, ultimately, expanding their minds (Collins, 1998). While developing the teaching style, the teacher should provide the conceptual knowledge and basic principles. Conceptual understanding gives a context for the application of problem solving methods. A student-centred style is more likely to motivate students by engaging their interest and developing abilities to work in groups.

In fact, teaching is part of a whole that comprises the teacher, the learner, the disciplinary content, the teaching/learning process, and the evaluation of both the teacher and the learner. Although there is no universal *best* way to teach, experience shows that some general principles apply (Committee on Undergraduate Science Education, 1997). These include:

- teach scientific ways of thinking;
- actively involve students in their own learning;
- help students to develop a conceptual framework as well as to develop problem solving skills;
- promote student discussion and group activities; and
- help students experience science in varied, interesting, and enjoyable ways.

Case study in *University Physics*

Until now, I have taught physics according to the traditional formats: lectures; discussion sessions; and laboratories. The students were the passive recipients of the information already acquired by the teacher. The students had merely memorised equations and problem solving procedures. Even though they generally got high marks, they were unable to answer basic questions. I began to rethink how I was teaching and realised that students were deriving little benefit from my lectures. Now I will change to teaching by case study (Hamel, 1993) and problem based learning (Woods, 1994). Student-centred teaching focuses on the student and, in particular, on the cognitive development of the student. The teacher's goal is to help students grasp the development of knowledge as a process rather than a product. Students create their own conceptual or cognitive models. Student-centred teaching combines an understanding of the way that humans process information with other factors that affect learning such as attitudes, values, beliefs, and motivation. Even though it is student-centred teaching, the teacher should have knowledge of three things: i) the material being taught; ii) the best instructional strategies to teach the material; and iii) how students learn.

The following is an example of a case study.
China's first manned spacecraft, the Shenzhou-5, blasted off from the Jiuquan Satellite Launch Centre in the northwestern province of Gansu. China's success in sending and returning to earth its first spaceman broke the dominance of Russia and the United States in manned spaceflight.

Beijing's Wangfujing Bookstore, located in one of the capital's most bustling central areas, introduced various types of pop-science books on stories as well as questions and answers about China's first successful manned space flight, which attracted more readers than usual and all sold well. Hot sales of spaceflight books also drove up sales in other science books. What kind of science books do you want? If you are invited to go with the astronaut, what preparation should you do?

Figure 1. China's first manned spacecraft, the Shenzhou-5, blasted into space

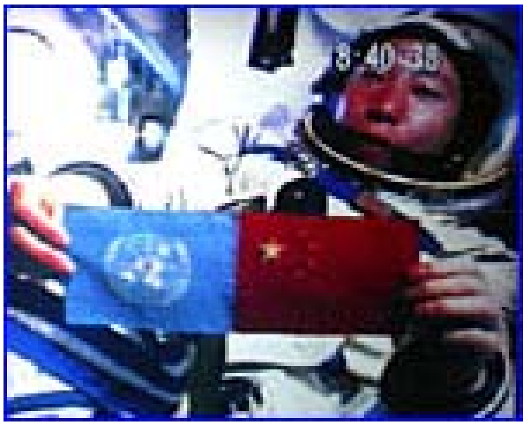

Figure 2. China's first space hero Yang Liwei

Concept mapping

Concept mapping is one of the most effective methods to help students identify the key and associated concepts of the problem and get a deeper understanding of the topic (Lanzing, 1997). I would like to use it in teaching *University Physics* at Tianjin University. Following a discussion of China's manned space mission and the interest generated in related scientific knowledge, we will build up a concept map, as shown in Figure 3. My students will be eager to learn it because it is indeed a very important and exciting event.

Some inter-disciplinary knowledge will be introduced into the concept mapping to broaden the content in my course. Science should be considered as intrinsically multi-disciplinary. Student learning is enhanced when we are able to help students see the relationships between the sciences. Multi-disciplinary concept mapping cannot only broaden student thinking and problem solving abilities, but also enrich the students' view of science as a multi-faceted enterprise (Committee on Undergraduate Science Education, 1997).

From the 'manned space mission' example, I would like to let my students see that humankind can do a lot with resources in space, including creating a physical world unimaginable on earth, discovering new materials and developing infinite living spaces and new life styles. From land, to the sea and into the sky, every move into the new frontier has significantly pushed forward human civilisation. With the first launch of Chinese astronauts into space, it is safe to say China is accelerating its race toward space.

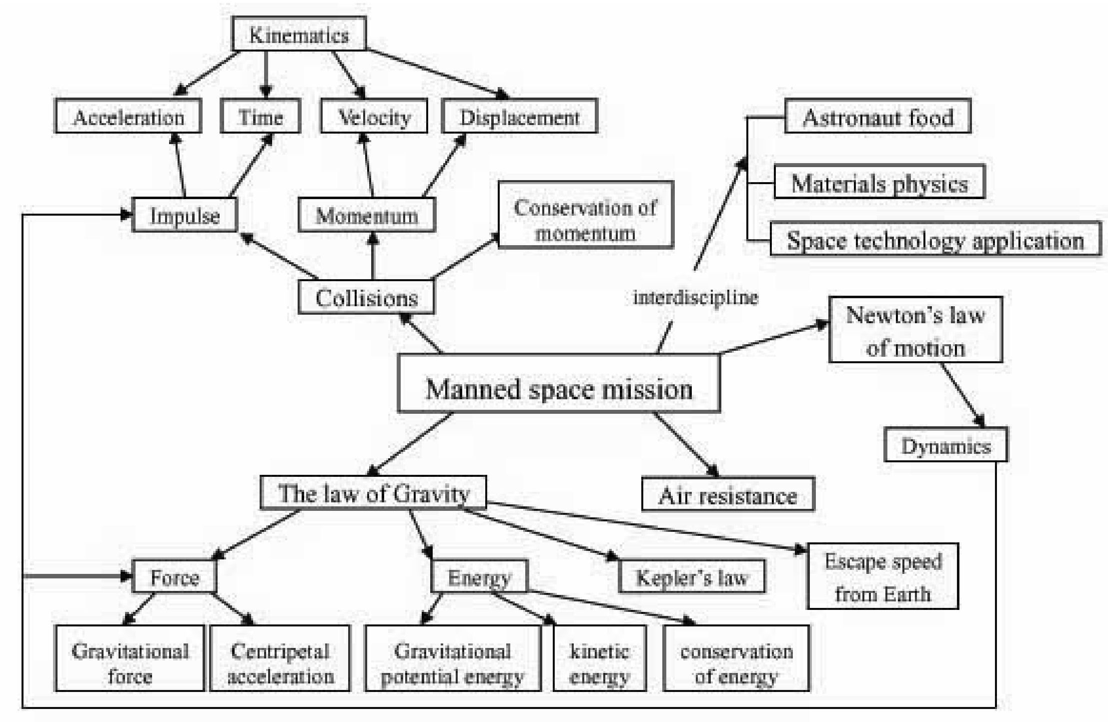

Figure 3. Concept mapping of manned space mission

Conclusion

University Physics is a core course for all the undergraduate students. Traditional teaching strategies are teacher-centred and need to be improved. In the teaching of this course, evolution is probably better than revolution. The combination of high-quality lectures and some contemporary teaching strategies can be used to make the students enjoy physics. I would like to introduce the new teaching and learning strategies in my *University Physics* teaching in China, because these methods focus on the students' attitudes, values, beliefs and motivation and are more effective. The work will be challenging and time-consuming. However, both teachers and students will benefit from these positive changes because learning is the goal of teaching.

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