

Using new strategies to improve teaching and learning in a *Fundamental Physics* course

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Abstract

Traditional approaches to teaching science have been in use for a long time. We will have to make changes in the teaching of science in China because the world is changing. What we must do is not only teach students knowledge, but also develop their problem solving skills and lifelong learning skills. Having completed the *Teaching Science in English* course, I now have an understanding of new teaching strategies and how they could be used to improve teaching and learning in physics.

Introduction

Physics is a fundamental science which is concerned with the basic principles of the universe. It is the foundation for other physical sciences. It is divided into five major areas: Classical Mechanics; Thermodynamics; Electromagnetism; Optics; and Modern Physics. The objective of physics is to: find a limited number of fundamental laws that govern natural phenomena; use these laws to develop theories that can predict the results of future experiments; and express the laws in the language of mathematics (Serway and Jewett, 2004).

Typically at Lanzhou University, the *Fundamental Physics* course would be delivered to a class of one hundred and fifty students. Usually *Fundamental Physics* is taught to first year undergraduate students in second semester. It consists of seventy-two hours of face-to-face teaching. In addition, there are two extra hours every week to solve students' problems. The course is assessed predominantly by examination, with the final examination contributing 80% of the final mark, and the remaining 20% of marks is from assignments.

In our university, many teachers use a traditional approach to teach science. Traditional physics instruction relies heavily on the use of drill and practice for solving numerical problems, requiring routine application of formulae and equations for the solutions (Tao, 1999). The teachers have to select the texts, and carefully prepare and present lectures. Assessment, testing and feedback are used to support this process. This is known as behaviourist style of teaching. For most of the teachers in our university, it is the preferred way to teach and learn science.

After attending the *Teaching Science in English* course, I have now come to realise that our current teaching practice is perhaps not the best way to develop a conceptual understanding of physics concepts and principles. Although we are trying to achieve the aims of the degree program, most students seem not able to deal with the problems in their work and adapt to the society well. Based on my experiences at The University of Sydney, I will discuss the use of contemporary teaching strategies to teach physics.

Traditional teaching strategy

Traditionally it was thought that students learn physics in small incremental steps and that each step builds logically, one upon the next (King, 2005). During the *Teaching Science in English* course, most of us had to admit that it is the easiest way to teach in our universities. In traditional teaching, it is easy to control the context and processing of learning because it is logical and sequential. In fact, this approach is a typical example of teacher-centred teaching. However, we all realise that there are some weaknesses in the traditional teaching approach. This approach to teaching often leads to surface learning as much of the content is too abstract and students find it hard to relate to real life. A Chinese proverb says 'We just see a small part; we can't see the whole picture'. It is the same here.

Contemporary teaching strategies

During the *Teaching Science in English* course, we were introduced to contemporary issues and research in the area of teaching and learning in science, including:

- Developmentalist and Constructivist learning theories;
- problem based learning approaches;
- case study and contextualised learning approaches;
- student-centred and collaborative learning;
- the use of online learning strategies; and
- curriculum developments in contemporary science teaching and learning.

These teaching strategies not only enhance the learning experience but also help students achieve lifelong learning skills, including problem solving skills which are essential to physics.

How should I teach in the future? Before answering this question, I should ask myself what I am trying to teach my students in the general physics course. The focus of this course is to introduce students to the basic concepts and principles in physics. The course is designed to help students develop appropriate methods of study that will allow them to become independent learners, capable of organising new information into a coherent conceptual framework and apply it in both familiar and unfamiliar situations. In addition, the general goal is to develop an interest in science, motivation for further study, and the ability to solve problems.

In promoting the sorts of skills we have discussed in the *Teaching Science in English* course, the most useful teaching strategies are: lecturing; group discussions; oral presentations; laboratories; critical review; problem based learning; self assessment; student-centred learning; concept mapping; team work; workshops; and case studies.

Improving teaching in physics

Teaching methodologies in the lecture

Language is one of the most important strategies for teachers in the classroom environment. It is important to recognise that our teaching strategies help students learn. In China, it is becoming very popular to use multimedia in teaching. Multimedia can be used in lectures to deliver digital instructional teaching materials incorporating graphics, sound and video and so enrich the course and engage the students. From my own teaching experience, most students think physics is the most difficult course they have to study. To supplement the use of chalk and blackboard, I plan to introduce slides, video, film and other multimedia material into my physics teaching. Then I hope physics will not be so boring for the students.

Problem based learning

Problem based learning is a curriculum design and a teaching/learning strategy which simultaneously develops higher order thinking, disciplinary knowledge bases and practical skills by placing students in the active role of practitioners (or problem solvers) confronted with a situation (ill-structured problem) which reflect the real world (Illinois Mathematics and Science Academy,

<http://www.imsa.edu/>). Using problem based learning can increase students' interest in the course and increase students' motivation in learning science. During the *Teaching Science in English* course, we discussed problem based learning in different disciplines. The problems designed for classroom use require students to: connect new knowledge to old; recognise what they do know and understand and what they do not know and understand; understand concepts enough so they can explain them in their own words; and be able to teach them to their peers.

Here is a problem designed for *Fundamental Physics*:

Have you ever been in a rotating chair? A person seated in the chair holds a heavy 'dumb-bell' weight in each hand, with arms extended. The chair is rotated and the seated person pulls his arm toward his body to increase the speed of rotation. The chair may be slowed by extending the weights.

You may see children enjoying a rotating chair greatly. Can you explain why drawing the weights in to the body will make the chair rotate faster?

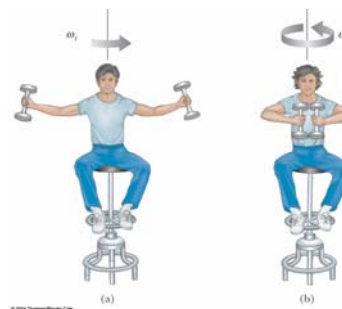


Figure 1. ROTATING CHAIR

Figure 1 shows the rotating chair (Serway and Jewett, 2004). This problem involves several concepts and principles of physics. Students should learn the concepts, ideas or issues which are central to the problem, then apply them to the real world.

Concept mapping

Concept mapping is one strategy employed to develop and improve teaching in physics. It is a tool for assisting and enhancing deep learning. A concept map is a special diagram for exploring knowledge, by gathering and sharing information. It consists of nodes or cells that contain a concept, item or question and links (King, 2005).

Figure 2 is the concept map of the problem above. The concept map can help the teacher establish whether or not the students understand the concepts that link the various pieces of information together. The concept map also helps students know what they have learned and what they still do not understand.

Team work and mini-lecture

Team work will give students the opportunity to consider what is involved in cooperative efforts and why real team work can be very effective. As a result, this is one of the skills which helps them become lifelong learners and problem solvers (King, 2005).

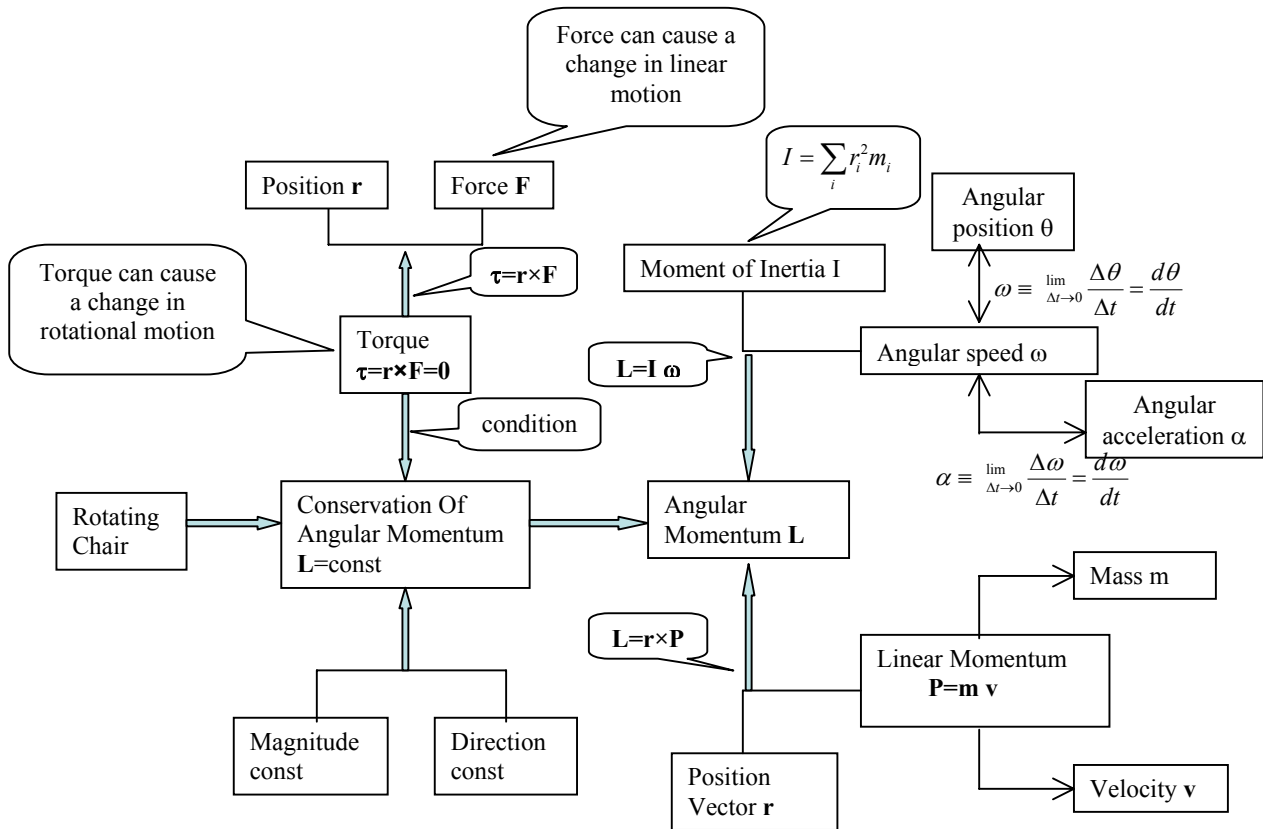


Figure 2. Concept map of the rotating chair

Students are divided into small groups, and each one decides on a topic during the course of the semester. The topics are based largely on lectures or other forms of conventional instruction. Each group will concentrate on one topic and collect relevant information from the textbook, library, Internet and other media. After a few weeks, each group will be required to give a mini-lecture about their topic and answer questions from the audience.

Team work and mini-lectures encourage students to be motivated learners and take responsibility for their own learning. These skills also help students retain as much as they can, as illustrated in Table 1 (Lagowski, 1990).

Table 1. Learning process retention rates

10%	What they read
26%	What they hear
30%	What they see
50%	What they see and hear
70%	What they say
90%	Something they say as they do it

Assessment

Assessment is an important aspect of both the student learning experience and the practicalities of providing fair and thorough feedback and, of course, assessment is the most powerful lever that teachers have to influence the way students respond to courses and behave as learners. (Gibbs, 1999).

If we change our teaching strategies in teaching physics, we need to consider changing the assessment. This should be based upon a combination of assignments, tests and

examinations. Table 2 gives the comparison of the assessment in the current and future models.

Table 2. Comparison of the current and future assessment

Assessments	Current	Future
Assignments	20%	10%
Quizzes	-	10%
Practical reports	-	10%
Mini-lecture	-	10%
Final examination	80%	60%

Conclusion

Although there are other teaching strategies, in this paper I have discussed my thoughts and reflections from my own experiences at The University of Sydney. These contemporary teaching strategies are very useful in improving teaching in physics. I will introduce these ideas to my colleagues at Lanzhou University. I hope my students will accept these and become real learners in the future.

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