Use of the Workshop Tutorial in teaching *General Physics*

Ping Zhang
Department of Physics
Beijing Normal University
Beijing 10088 China

bnuzhp@sina.com

Manjula Sharma
School of Physics
University of Sydney
NSW 2006
Australia

Abstract

The 'Workshop Tutorial' is an interactive, cooperative, student-centred classroom environment, which accommodates a wider variety of student learning styles. Based on the innovation of the *General Physics* course in the Department of Physics, Beijing Normal University, this paper discusses how to use the 'Workshop Tutorial' in teaching General Physics, and how to develop the students' learning skills such as: self-directed and lifelong learning skills, research skills, communication skills, critical thinking skills and teamwork skills.

Conventional circumstances

General Physics is a two-semester service course that covers mechanics, thermodynamics, electromagnetism, waves, optics, and contemporary physics. Contemporary physics includes quantum mechanics, relativity, nuclear and atomic physics. This is a course for first year students. It is based on the concept that physics is the foundation of all sciences. The course argues that everyone should study physics in the 21st century, especially those who will develop or apply science and technology in their lives and work. Physics may be considered to be at the core of university science education in the 21st century.

In our university, students attend a 3 hour lecture and 1 hour laboratory session (3-4 hours) per week. Homework is assigned weekly and examinations are given twice during each semester. In general, the teachers are expected to complete all the content in a specified textbook. Present textbooks emphasize facts, concepts, theories, logic in physics and often neglect other important aspects of physics, such as the ability to use the processes of physics to solve real world problems and the ability to make value judgment and decisions on physics-based societal issues.

There are two teaching methods currently in use at BNU. One is the 'lecture' in which the teacher transmits information to hundreds of students and students do not have any opportunity to communicate with their teacher in the class. Another is the 'laboratory'. Students spend a long time (3-4 hours) finishing the experiments selected and arranged for them by their teachers. Some students say that they feel lonely and bored because only one person (one person in a group) does many things repeatedly as the set experiments often require a lot of data collection. The advantage of these two methods is that they are easy to deliver, organise and control by the teacher. The students have to learn what their teacher wants them to learn because their teacher designs the final examination. The conventional teaching methods in *General Physics* can therefore be seen to be essentially teacher-centred.

Modifying the teaching methodology of *General Physics*

A number of innovations are currently underway in our university in China. Firstly, the beginning of the physics course was moved from the first teaching semester to the second. This reduced the problem of students not having learned enough calculus to cope with the course. By moving it to the second semester a certain level of mathematical skills could be guaranteed. Secondly, BNU was awarded the project 'Face 21st Century Physics Teaching reform' supported by the Ministry of Education of China (1999). This program required us to focus on using recent physics research and relating this to the content of our teaching. Consequently, many topics included in the textbook have been revamped. The emphasis is now on explanation of real practices and expansion of contemporary knowledge in physics. The new textbook was published in China in 2002. Thirdly, a lot of work has been done in preparing computer assisted instructional materials in order to deliver more information in the lecture situation through the use of multimedia techniques. Teachers were encouraged to teach vigorously especially in linguistic arts. The result of these innovations in the basic physics course is that the textbook has changed and the lecture 'blackboard' has changed too. But the teaching methods

themselves have not changed. They remain essentially teacher-centred. The physics lecturing staff at BNU put a lot of thought into what should be delivered to students and what is the best way to teach it. Clearly more could be done in this area because we also want our students to get more out of physics classes than just 'the physics content' we want them to be engaged in making sense of physics and to develop a deep level understanding of these ideas. In order to achieve this we also need to think about how students learn and assimilate information.

The China Higher Education system also faces an additional problem in that in many cases the learner is an only-child (due to the one child policy). In order to pass the highly competitive University Entrance Examination they struggle to understand and perfect what their teacher would like them to learn, and what they would like them to learn is directly related to examination success. Consequently, they are learning with high levels of anxiety and stress before enrolling in university. Therefore, by the time they do reach university they haven't developed skills such as: self-directed study, lifelong learning skills, research skills, communication skills, critical thinking skills, and teamwork skills. They have grown up and succeeded in a system that essentially does not reward these skills.

It is difficult for us to help students to develop the above skills by traditional modes of teaching. The students are by definition passive recipients when we approach our teaching by 'pouring' information directly into a student's head, and in particular in a class size of a hundred plus students. They will struggle to gain a deep understanding of basic physical concepts, and they do not have the opportunity to communicate with each other or with their teacher. Science education reforms suggest teacher-centred lectures are less effective with regard to deep level processing of information when compared to student-centred active learning. Workshop Tutorial (Sharma, Millar and Seth 1999) provides a more interactive, cooperative, student-centred classroom environment that accommodates a wider variety of student learning styles.

Workshop Tutorial: a valuable learning environment

The Workshop Tutorial class is an additional method that can be used in teaching *General Physics* in addition to the lecture and laboratory.

General Features of Workshop Tutorial

This method uses group learning with carefully designed worksheets (Sharma, Wilson and Millar 2001). The Workshop Tutorial classroom is arranged as shown in Figures 1 to 5. Students work in cooperative teams discussing and researching problems according to the worksheet. There is hands-on demonstration equipment relating to the problem in the rooms which students have constant access to, and also staff tutors students are present in the workshop.

Figure 1. Workshop tutorial classroom

Figure 2. Worksheets are placed near the door

Figure 3. Hands-on demonstration equipment

Figure 4. Teamwork

Figure 5. Staff tutor the students

Workshop Tutorial class has somewhat different characteristics

The Workshop tutorial is designed to shift learning from a pure lecture method to student-centred instruction using hands-on activities. Students complete activities designed to help them develop an understanding of both experimental and theoretical aspects of physics for themselves. The design of the activities is based on the outcomes of physics education research. Research shows (Sharma, Millar and Seth 1999) that the Workshop Tutorial helps students learn concepts better than only traditional instructional methods. The Workshop Tutorial class has somewhat different characteristics than the lecture, as listed below.

- **The method is student-centred**

In brief, the student-centred approach is based on the hypothesis that students who are given the freedom to explore areas based on their personal interests, and who are accompanied in their striving for solutions by a supportive, understanding facilitator, not only achieve higher academic results but also experience an increase in personal values, such as flexibility, self-confidence and social skills. This approach, also known as experiential learning, requires specific personal attitudes on the side of the instructor who takes over the role of a facilitator. These attitudes are highly transparent, open communication, positive regard towards students and the seeking for deep understanding (Rogers 1983; Aspy 1972). Students in the Workshop Tutorial are allowed to openly discuss and work on problems, to explore different avenues of solution without pressure. The control and responsibility for learning is with the students.

- **The students work in cooperative teams**

Cooperative learning is a successful teaching strategy in which small teams, each with students of different levels of ability, use a variety of learning activities to improve their understanding of a subject. Each member of a team is responsible not only for learning what is taught but also for helping team-mates learn, thus creating an atmosphere of achievement. Students work through the assignment until all group members successfully understand and complete it (Samiullah 1995; Webb 1989; Tao 1999).

- **Learning model is of the 'discovery' type**

That is, students are guided to observe phenomena and build for themselves the fundamental idea via observation. Many students simply do not absorb, understand, or remember material that a teacher explains at the board in front of a class. The students in the Workshop Tutorial are given opportunities to discover how to do something on their own (or better still, in groups), they will generally have a much deeper understanding of the concepts being studied.

Use of Workshop Tutorial approach in teaching in *General Physics* in China

I became interested in this Workshop Tutorial approach to teaching when I saw an article (Sharma, Millar and Seth 1999) on the Internet. I attended one such Workshop Tutorial session at the University of Sydney in 2003, and would like to adopt it in the *General Physics* course when I return to Beijing Normal University. I watched students getting excited about learning. Students' reception of this course has for the most part been positive, and tutors overall enjoy tutoring this way. Students have a variety of learning styles, and no instructional approach can be optimal for every one. Workshop Tutorial approaches should be seen as supplementing traditional methods and providing an opportunity for a greater degree of deep level processing of information. It cannot replace the lecture or the laboratory sessions. However, we can use its characteristics in developing important generic skills in the student that I have described earlier. In order to do this we need to understand how this learning environment fosters these skills in the *General Physics* course at BNU?

Environment well suited to interaction

The Workshop Tutorial environment should be centred on students, and provide for a variety of learning styles to be displayed by the student body. This is shown in Figure 6.

There are books, computers, demonstration equipment and tutors in this environment. The environment is specifically designed for promoting interaction between students, tutors and resources in order to support the learning process. Students can work and learn in different ways such as by reading (book and Internet), by listening (other team-mate's explain or critic, tutor's question), by speaking (their view to others), by writing (draft on butcher's paper) and especially by doing (experiment). This causes students to open their minds. Particularly helping students to develop

concepts and create logical arguments. The demonstrations are carefully chosen to illustrate particular concepts in physics. The role of the tutor is to support students by asking questions, rather than by simply giving answers. Many of the tutorials are paper and pencil worksheets. The Workshop Tutorial at the University of Sydney used 'hands-on' demonstrations. I think in China I will add computer (Internet, cybertutor) and bookshelves to my classroom. 'The door' of the tutorial is always open, i.e. the students are encouraged to visit museums, science centres, libraries, factories, and other universities to find ideas and information if they cannot solve the problem indoors. Learning is a lifelong process. When it comes to opening their minds, we should not shut the door!

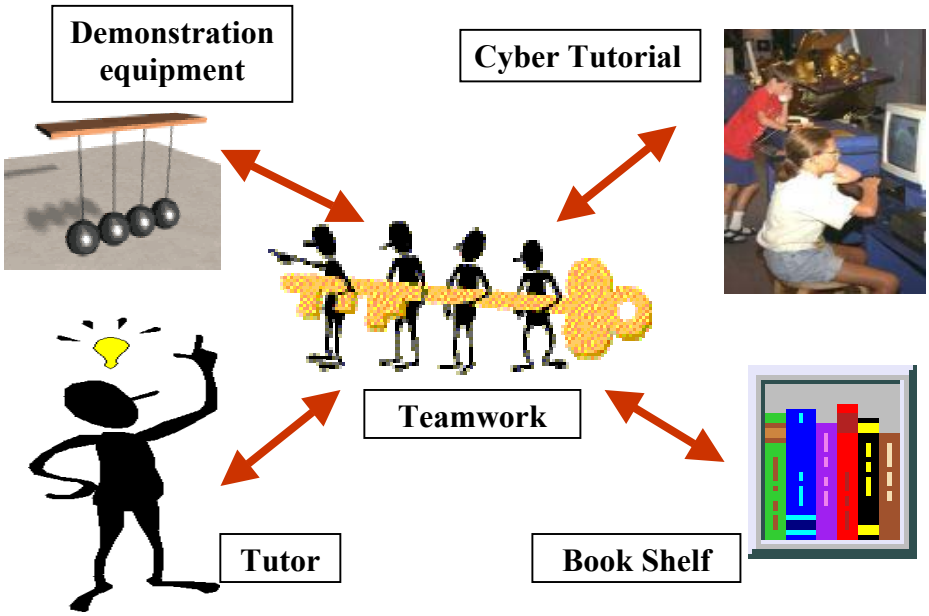


Figure 6. The Workshop Tutorial environment

It all begins with a question

In order to learn we must begin by asking a question. It is essential. Students go through the tutorial worksheets and questions step by step in the Workshop Tutorial class. In order to engage the student in the learning process we need to encourage them to ask questions about physics which is around us in everyday life (King 2003). The questioning style should promote not only teamwork amongst the students but also lead them to a more 'discovery' method of learning.

- **From life to concepts of physics**

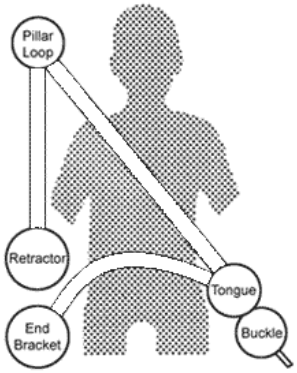
For example: Would you like to reduce or increase the frictional force?
This topic is based on a students' own experience in their lives. Everyone in the group could put their experiences forward. Their physics concepts are polished after they discuss and criticize each other.

- **Concept of physics use in life**

For example: What is the conservation of momentum?
Applying the same ideas in different contexts helps reinforce their understanding. The question assigned after the lecture provides additional practice in applying the ideas. The example is given in order to evoke the sociability of the student. In essence, this is the notion of learning transfer, i.e. that a student can truly be said to have understood a concept when they can apply that concept correctly in a range of different circumstances.

- **Open-ended question**

The teacher should have the ability to connect the basic concept to many real world problems, or be able to find concepts related to curriculum from our surroundings and use these interesting problems as instructional materials.



For example, on the bus during our excursion to Canberra, one tourist could not pull out the seat belt because the seat was tilted. At first, none of us knew the cause and thought that the seat belt was out of order; finally we noticed the seat was tilted. Of course, the belt was pulled out when the seat became straight. In considering how the seat belt works and the above process I thought it might be a good example for teaching. After searching for information and regarding the working mechanism of the seatbelt, I found it a really interesting problem for Workshop Tutorial. We would provide a bus seat equipped with seatbelts in our workshop, and propose the following problems:

- imagine the working mechanism of the seatbelt;
- dismantle the retractor and describe its structure;
- analyze its working principle; and
- discuss the working principle and try to use it in other situations.

Simple description of the seatbelt working principle
Principle: using the inertia of objects
Function: stopping the belt in the following cases
If the retractor (fixed on the car or seat) slopes over a certain angle (11°)
If the belt is pulled out with the acceleration over certain magnitude (0.7g)

Cooperation is essential

Cooperative learning is not simply a synonym for students working in groups. The students must know why cooperative learning is important in physics. So the following strategies will be used:

- First, Workshop Tutorial sessions will be designed to discuss the following questions:
  - what is cooperative learning?
  - what are the specific elements of a successful cooperative learning activity? and
  - who benefits from it, weak students or strong students? what are the benefits they will receive?
- Some reference papers or multiple choice questions will be given to the students. Printed instructions on how to work cooperatively in a team is given to students before the end of class. The first sentence is 'All for one, one for all'.
- The worksheet is designed for the individual and the team. So there are four individual and one team worksheet in a group (four students). Sometimes individual worksheets are different (No 1, 2, 3, and 4) for guiding the students towards presenting different ideas and gaining from each other's efforts. By the end of the class they should be able to answer the questions on the team answer sheet. They must recognize that all group members share a common fate.
- The team worksheet, individual worksheets and butchers paper (placed on the group's desk for draft work) should be handed in together. Marks are given to the team for arriving at correct answers as well as for their cooperation and teamwork.

Future works

The Workshop Tutorial will be a new and innovative teaching strategy in our university in China. This idea might best be introduced as a concept by publishing a journal paper. In this paper the broad outlines, characteristics, intentions and potential benefits of the Workshop Tutorial approach will be explored. We could then design a number of Workshop Tutorial units that would act as examples for colleagues and students alike, with interesting questions and simple equipment. In the first instance I believe that it should be trialed with a relatively small class thus providing the opportunity to reflect on the practice and develop the necessary teaching skills. Feedback from the students and staff should be researched again in China. I want to tell my colleagues about the Workshop Tutorials. I want to set up a new course, which will need demonstration equipment and the resources necessary for success. The new course will also require financial support, so it is necessary to apply for funds for the project. Whilst these are the normal problems associated with any curriculum innovation, the introduction of an innovative teaching approach will give the enterprise an added attraction for participation with and by my colleagues.

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