

Using problem based learning in *Electrical Engineering Foundation*

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Abstract

Problem based learning (PBL) is a curriculum design and 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 reflects the real world (Illinois Mathematics & Science Academy, 1994).

Based on the review of the current state of teaching in *Electrical Engineering Foundation* in Sichuan University, this paper discusses how to use PBL strategies and other methods to improve the quality of teaching and solve the problems associated with an apparent lack of interest in this course from non-electrical engineering students.

Introduction

The world is at a time of information explosion. Everywhere there is new information or knowledge being created or rediscovered in: science; communications; medicine; transportation; literature; – the list goes on. The rapid explosion of knowledge, increased technology and social complexity is such that current and even future students cannot learn all the essential knowledge for their future working lives. Many students wonder what they should learn. In fact students need to know more about how to learn than the knowledge itself. We need to help them develop the necessary learning strategies.

To address the problems identified, many strategies are presented including: case studies; concept mapping; PBL; independent learning tasks; small group inquiry/investigation tasks; role play; simulations; interactive teaching/learning sessions; discussion and questioning; laboratory investigations; programmed instruction; community activities; plus a mixture of mini lectures and traditional lectures. Of all the strategies discussed, PBL appears to be especially suitable for engineering courses.

Principles of PBL

The most important part of PBL is an appropriate problem which comes from the real world and has a relationship with the course. It can stimulate students' interest and encourage activity. By posing an engaging and very challenging problem before students have begun studying a subject, PBL teachers encourages students to work together to find potential solutions to the problem by pooling their resources. Often the practice of PBL involves each student groups being assigned their own homework in order to research a question. For PBL to work properly, the questions must be complex enough so that there is no one 'right answer', but rather a group of potential answers and strategies so that interdependence and communication are enhanced (King, 2005).

PBL makes students more engaged in learning because they are 'hard-wired' to respond to dissonance and they feel they are empowered to have an impact on the outcome of the investigation (i.e., they assume more responsibility for learning).

PBL offers students an obvious answer to the questions, 'Why do we need to learn this?' and 'What does what I am doing in school have to do with anything in the real world?' The ill-structured problem scenario calls forth critical and creative thinking by suspending the guessing game of, 'What's the right answer the teacher wants me to find?'

PBL promotes metacognition and self-regulated learning by asking students to generate their own strategies for: problem definition; information gathering; data-analysis; hypothesis-building and testing; and comparing these strategies against; and sharing them with other students' and mentors' strategies.

'PBL engages students in learning information in ways that are similar to the ways in which it will be recalled and employed in future situations and assesses learning in ways which demonstrate understanding and not mere acquisition.' (Farina, 2003; Gick and Holyoak, 1983).

PBL is use in the course because:

1. *Electrical Engineering Foundation* is a practical engineering course which is designed for the non-electrical engineering students. As it is closely related to the real world, it is relative easy to find realistic and interesting problems to use in PBL in *Electrical Engineering Foundation*.
2. Most fields of science and technology needs a course such as *Electrical Engineering Foundation* to some extent. In our university, and in most Chinese universities which have science and technology disciplines, such a course is compulsory and is undertaken by thousands of students. As problems of the real world are becoming larger, multi-disciplinary, and more complicated, it is a better strategy to use PBL which provides collaborative learning.
3. While this course is compulsory for non-electrical students, it is also a major. Traditional teaching strategies involving too many lectures, homework, and testing laboratories can be very boring. Many students learn the material at a surface level only, recalling the knowledge for assessment. By using interesting real world problems, PBL can increase students' interest in the course and their motivation to learn science, make students more active learners, improve students' problem solving skills and 'lifelong' learning skills.

Course description

This course introduces the basic concepts and techniques of electrical engineering to non-electrical engineering students, and it is the only electrical engineering course for these students during their university undergraduate studies. Consequently, this course has to cover vast areas of electrical engineering however, the workload for students is controlled. It is, therefore, extremely important to carefully design all aspects of teaching and learning in order to improve the quality of the course.

This unit of study assumes basic research skills and the ability to grasp engineering principles; information literacy; personal and intellectual autonomy; communication skills.

A well designed structure of the course is crucial for students to deal with the vast materials. After a careful study of the experience of participants in similar courses in previous years, it has been decided to 'decentralise' this course into three blocks (parts), with only limited connections between them. These blocks will be taught in sequence but quite independently (Hu, 2005). Figure 1 shows the division of this course.

Current teaching methods

Previously, although we have been striving to focus more of our teaching on activities that involve the students, the teaching strategies used are mainly teacher-centred: students just listen to lectures which cover knowledge in detail, work too many standard problems for homework, and memorise facts for examinations. They spend little time understanding the concepts behind the material. They are not aware of the relationship between the knowledge from this course and the real world especially in their major area of engineering. Therefore, they lack interest and they learn in a surface level. After the course, they forget most of what the course covered. So, it is not uncommon in China that there are many students who gain high marks but have low ability.

Modification of the course

The China Scholarship Council and The University of Sydney gave us a unique opportunity to not only learn how to teach science in English but also how to teach it effectively. As well as behaviourist strategies, we studied constructivist strategies, developmental strategies, and concept mapping. These are the contemporary strategies being employed in tertiary education in the west, and have been proved to be effective. We believe that we need to change our teaching approaches to improve our current teaching strategies and that PBL is an excellent strategy to improve the course *Electrical Engineering Foundation*.

As this course can be divided into three relatively independent blocks, I have designed three real world problems which will cover most of the content of this course. Table 1 shows the problems and contents of *Electrical Engineering Foundation*.

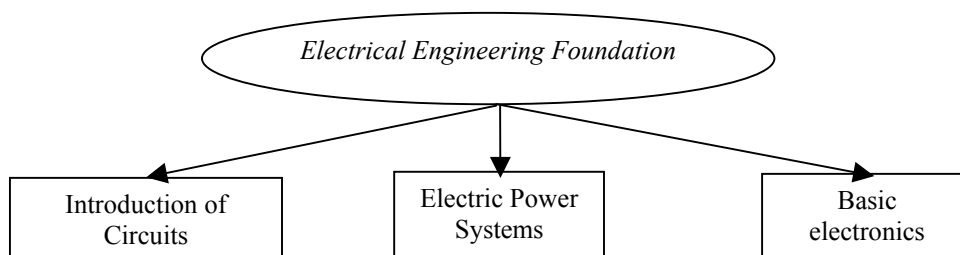


Figure 1. Course division

Table 1. The problems and contents of *Electrical Engineering Foundation*

Problem	Content
How to charge a weak battery car using a strong battery of another car?	current and voltage, power, Kirchhoff's Laws, sources and resistors, Ohm's Law, series and parallel connections, voltage and current divider, equivalent circuits. Inductors and capacitors: capacitance, inductance, RC circuits, RL circuits, introduction to RLC circuits.
Doesn't the KVL fit for AC circuits?	sinusoidal signals, effective (rms) value of sinusoids, power in ac circuits, transformer principles and ideal transformers, balanced 3-phase circuits. Electromechanical machine types, DC machines, field connections, introduction to ac and induction machines.
Why can we hear the music by the radio?	Op amp, inverting amplifier, noninverting amplifier, basic op-amp circuits. Digital circuits: digital signals, truth table and basic logic functions, Boolean function, digital circuit design and realisation.

In illustrate the strategy of PBL, I will use as an example from this problem – the first task. During the first class, students will be divided into several groups, and they will be given the problem.

Problem

You and your friend each drive a car on a long trip. When you are at a isolated and uninhabited place, your car will not start because of low battery voltage. There are no repair shops and no residents. What can you do? If your friend's car has a fully charged battery, you can use his battery to charge yours. Look at Figure 2, how should you connect the two batteries? Be careful, an incorrect connection may result in the two batteries being destroyed!

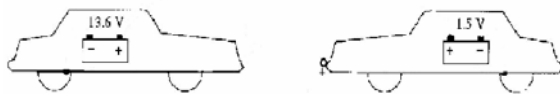


Figure 2. Car batteries connection

Students within each group will work together to try to find the solution. They will go to the library to find some relevant books and journals, and they will need to consider why and how. It will take several weeks to solve the problem. During that period, I will give them some lectures explaining key concepts and analysing methods they need for the solution, also tutorials and laboratories. Figure 3 shows the concept map for the first task within the problem.

Lectures

As PBL is a student-centred strategy, and with the teacher's role being more that of an instructor than a lecturer, lectures will be reduced to a relatively small amount. During the lecture sections, the key concepts and principles of analytical methods, such as, in the first problem, the directions of the current and the voltage, the power, Ohm's Law, and Kirchhoff's Laws, will be discussed but not all of the concepts and methods. Students will be introduced to *WebCT* where there will be relevant materials, as well as the Internet and library. In order to give them more time for self-learning, and discussion, we will assign less homework than previously.

Tutorials

Tutorials provide students with the best way to understand the concepts and gain skills of solving circuit problems. Tutorial questions are a good indication of what may be required for tests and although group work is encouraged in the tutorials, students can ensure that they can solve them individually. Tutorial questions will be selected from the textbook and will be published on the course web page before the tutorial time allowing students some time for preparation and identifying any questions with which they need help.

Laboratory work

Laboratory work forms an important part of this course. It helps students to connect the theoretical results gained in lectures and tutorials with the physical world. Experience shows that laboratory work stimulates students' interest and deep understanding of the course materials.

Seminar

During the seminar section, students will share the information they have found, discuss the problem and exchange their ideas. Using the newly acquired information they work towards a solution to the problem. Seminars make students work collaboratively, and collaboration is very useful for students' future professional life.

Summary

As the course *Electrical Engineering Foundation* is not within the students' major area of specialisation, it is not surprising that the students have little interest in the course, and that they approach the learning experience passively and the effect of teaching is not as effective as it might be. Research has provided us with more and more teaching strategies, and now most contemporary teaching strategies are student-centred. Among these strategies, PBL is an appropriate one for *Electrical Engineering Foundation*, a course being undertaken by non-electrical engineering students. PBL can increase student interest and involvement. We hope that by using PBL in this course, we can increase students' motivation, make the students more active learners, and even help them to develop lifelong learning skills.

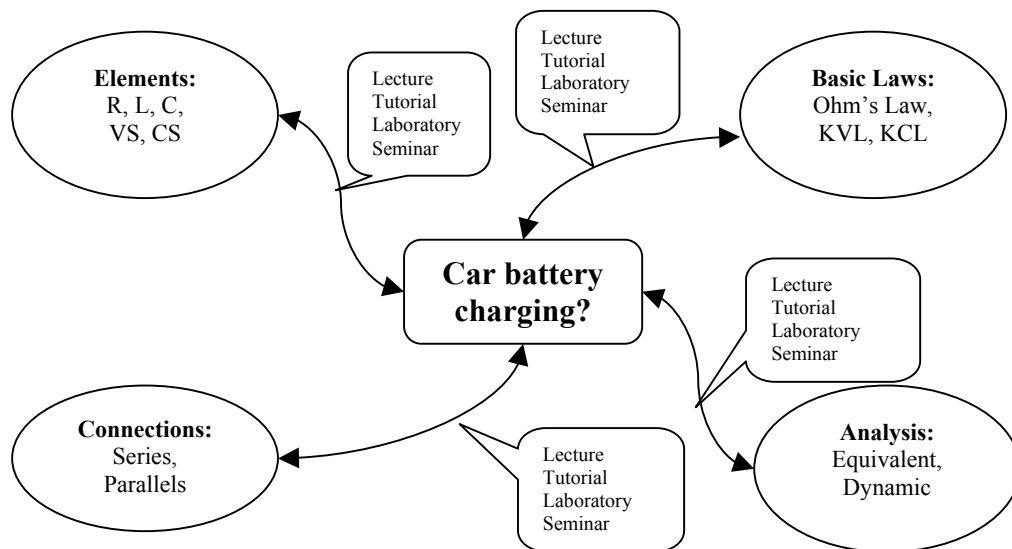


Figure 3. The problem based concept map of task 1 of the problem

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