A reconsideration of the teaching strategies in *Basic Theory of Circuits*

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Abstract

This paper provides a reconsideration of the strategies used in the teaching of *Basic Theory of Circuits* in Shanghai Jiao Tong University. Through a comparison of what has been done and what should be done, an achievable student-centred learning strategy is planned as an important guide for further reforms.

Introduction

With the explosion of knowledge in the last two decades, more and more scientists are being influenced by the research on different approaches to learning and teaching. What should students learn? How could they learn more? These questions are becoming more and more important in guiding the adoption of education approaches. As we know, learning is no longer restricted to school or university, but it continues all through one's life. The old learning and teaching strategies are no longer suitable for the students. What students should learn is not only the knowledge but more useful skills, such as lifelong learning skills, problem solving skills, critical-thinking skills, self-directed learning, cooperation and communication skills (Wang, 2004). So building a new effective teaching and learning system is an urgent task in the field of education. As one of the most famous universities in China, Shanghai Jiao Tong University has already begun its teaching reform. Teachers are required and encouraged to improve their teaching methods to promote active learning in their students.

Basic Theory of Circuits is a compulsory fundamental course for all the students in Electrical Engineering. The aim of this course is to enable the students to understand the basic rules and methods of analysis and so provide a solid basis for further study. It is the first major course in their discipline which requires a great deal of effort from the students to understand completely. Unfortunately most students find it difficult. They think that the lectures are boring, full of formulae and new concepts, and the content is too broad and too complicated.

In our *Basic Theory of Circuits* teaching group there are eight teachers who are in charge of the teaching and learning of the 1000 students undertaking this course. We started course reform several years ago. A lot of work had been done on different aspects, which resulted in some increased efficiency in teaching and learning. After a systemic introduction to science teaching and learning approaches at The University of Sydney, I now realise that we are far from our goal. I would like to critically consider different aspects on what we have done and what we should do in the future.

Problem based learning makes the lectures attractive

Slides have replaced the use of blackboards and chalk, making the lectures clearer and more colourful. Students are able to download the slides and review what has been learnt after class. However it is still a traditional teacher-centred activity. All concepts and principles are still provided by the lecturer one by one. Teachers feed information to the students in a convenient way. What we should be doing is to make the students active in their learning. According to the contemporary education theories, problem based learning (PBL) is an effective way to stimulate students' interests and to motivate self-directed learning. By posing the students an engaging and very challenging problem before they have studied a subject, PBL teachers induce students to work together to find potential solutions to the problem by pooling their resources. Problem based learning is a specific strategy for engaging students in collaborative learning (King, 2005).

The content of *Basic Theory of Circuits* can be divided into three parts: Resistance Circuits; Dynamic Circuits; and Sinusoidal Steady-State Circuits (which is the most complicated and difficult to understand). There are many mathematical concepts and calculations (such as complex numbers and vectors) included. Most students think it is too abstract and have no interest in it. Problem based learning might be an effective way to make lectures attractive. When using PBL strategies, a real-life situation is presented and students are faced with solving a problem that is related to their daily life.

This is a possible problem:
*A student who is living alone near campus complains on the BBS (Broadcast Board System) that this month his electricity bill is almost twice the cost for the previous one, although he has used about the same amount. He also finds the voltage provided has stayed at a lower level than normal. He thinks that as the voltage is low, it requires more amps to deliver the same wattage as it would with normal voltage. Since consumption is based on kilowatts, it is obvious that the same usage (of lights, refrigerators, water heaters, air conditioners, etc.) will result in more kilowatts used. But another student replies. He thinks that most single-phase induction type meters actually measure instantaneous power. They do not just measure current. The speed of the disk not only depends on the current being used, it also depends on the line voltage. Therefore, theoretically for these meters, the speed should not change, and therefore you are not being overcharged (*http://dr1.com/forums/showthread.php?t=24798*). They are arguing on the BBS. As an engineer, can you help them?*

To solve this problem, the students actually need a basic knowledge of some concepts of AC circuits (Figure 1). How does the consumption meter operate? How do electrical appliances absorb energy? The students should know how to calculate the power in AC circuits, and basically they should have the concepts and knowledge of AC circuits. Students eager to understand the situation are motivated to investigate. During the lecture, many teaching and learning strategies such as group discussion, case study, cooperative exercises and questions should be applied to develop a student-centred learning environment.

Extend the course web site to an e-learning system

Realising the important role of the Internet, we have built a course web site including several items:

1. Announcement (where the lecturer posts the notices);
2. Staff (teaching staff introduction);
3. Policies (including course objective, topics covered);
4. Lecture Notes (including all handouts and *PowerPoint* slides used in lectures);
5. Assignments (with completed solutions later);
6. Software (introduce the software which may be used for analysis); and
7. Feedback (students can communicate with the lecturer by email).

Although the web site we built is much better than not having one at all and does actually benefit students, its function can be extended and enhanced. We can rebuild it as an e-learning system. E-learning is playing a more and more important role in student-centred learning environments. E-learning most often means an approach to facilitate and enhance learning by means of personal computers, CD-ROMs, and the Internet. This may include email, discussion forums, and collaborative software. E-learning may also be used to support distance learning through the use of WANs (wide area networks). It can be very supportive for students' self-study. Our web site should be enhanced by providing access and support in the form of: a discussion forum; case studies; self-evaluation of formative assessment and links to resources.

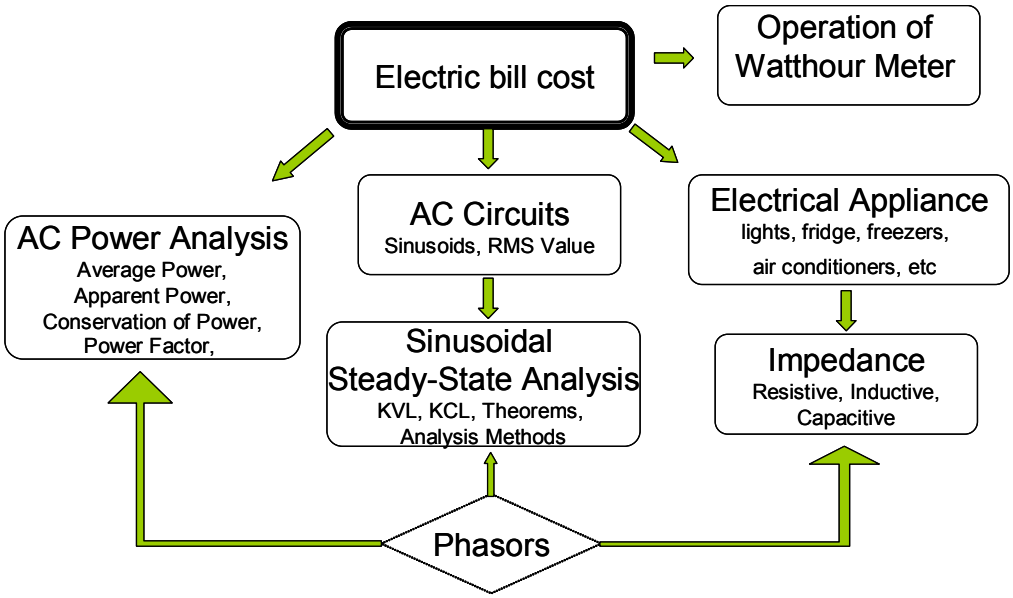

Figure 1 Conceptual Map on PBL

Discussion forum
Students and teachers can post their questions, solutions and problems and discussion would be encouraged. It is more instantaneous and effective than using email for communication. All student are able to benefit as it is open to them all.

Case studies
The use of case study is another increasingly popular way to engage students in science learning. The problems used in case study should be scientifically real problems, specific and focused. Case studies could be selected and specified by the lecturers with specific questions which relate to the curriculum. For those difficult principles, case study is an excellent way for students to enhance their understanding. As lecture time is limited, the cases can be posted to the web site in association with the relevant contents.

Self-checking
An exercise or quiz with a self-checking facility could be set for students after each chapter. The online system could be designed to mark the answers automatically and provide feedback.

Resources links
Direct links to resources on relevant knowledge within the course should be provided to make it easier for students and teachers to access what they require.

University assessment should focus on the skills instead of memory

Currently we still use traditional methods to assess students' learning i.e., giving a mark which depends mainly on a two-hour final examination. It is simple, but is it a good method for assessment? What do you want your students to achieve from the course? More and more teachers are becoming aware of the 'unrealistic' nature of examinations and are doubting their validity as a method of assessment. It is recognised that examinations emphasise memory and working within time and resource constraints which may limit their usefulness as tests of higher level understanding. It might be unfair to those 'non-traditional' but brilliant students who demonstrate their ability and achievements in other ways. They may not possess the same skills in passing examinations as 'traditional' students (McDowell, 1995).

In order to make a more realistic and fairer assessment of students' achievements, we should try some new forms of assessment: open-book examinations (which place more emphasis on problem solving than closed book examinations); oral presentations (which can also evaluate students' deeper understanding, critical thinking as well as being able to explain clearly); group projects with peer assessment (a more effective way to evaluate students' abilities of analysis and synthesis, and also judge their cooperative ability and computer skills as well).

Conclusion

As *Basic Theory of Circuits* is one of the most important courses for students majoring in electrical engineering, the teaching group meets and discusses the teaching strategies every two weeks. Although we have done a lot to improve our teaching, when considered in relation to contemporary education theories, it has been minimal. The first thing we should do in the future is to change the concepts in teachers' minds, that is, to turn our current teacher-centred strategies into student-centred strategies. PBL, case studies, group projects in lectures, an e-learning system outside of classtime, and establishing a realistic assessment scheme, are all necessary for and beneficial to stimulating students' interests and motivating self-directed learning, therefore building a student-centred learning environment.

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