Improving students' lifelong learning skills in *Circuit Analysis*

Weijie Dong
Department of Electronic Engineering
Dalian University of Technology
Dalian 116023
People's Republic of China

Abstract

Lifelong learning skills are of wide concern in tertiary education. Fostering these skills requires reconsideration and changes to traditional approaches to teaching and learning. This paper discusses how to improve students' lifelong learning skills in the course *Circuit Analysis*. In the past I have used traditional teaching methods to develop students' engineering problem solving and lateral thinking skills. I plan to incorporate student-centred approaches such as interaction in lectures and tutorials to develop students' communication skills and teamwork abilities. These skills will play important roles in students' future professional lives.

Introduction

We are living in a time of knowledge explosion. Universities or colleges are unlikely to be able to teach all the essential knowledge a student needs for their whole career within a four-year period. Moreover, much of the knowledge students learn in university will be out of date when they leave, because of the rapid technical developments. This means the students have to master a self-learning method and a set of lifelong learning skills in order to meet the demands of their future professional lives. Quality teaching and learning in tertiary education should aim to develop students' lifelong learning skills. Each teacher should make a contribution in developing these skills when teaching a certain course. This paper discusses how to teach lifelong learning skills in a course in which I am involved, *Circuit Analysis*. The relevant lifelong learning skills are discussed, together with a comparison of the difference between knowledge and skill. Consideration is then given to the question of how do we teach students these skills. One single approach is not superior to other approaches in all situations, nor is it appropriate to all subjects. The objectives and characteristics of *Circuit Analysis* are then analysed. After that, I reflect on the positive aspects of my current teaching practice, as well as those which should be improved in the future. It is concluded that more student-centred teaching strategies need to be incorporated in order to promote lifelong learning skills.

Lifelong learning skills

'Lifelong learning skills' refers not to the specific information that students acquire during their formal education, but to how successfully they can continue to acquire information after their formal education has ended.

What are the lifelong learning skills?
Lifelong learning skills include but are not limited to:

- self-directed learning skills;
- ability to seek out and assess information;
- critical thinking skills;
- lateral thinking skills;
- communication skills;
- interpersonal sensitivity;
- problem solving skills;
- ability to do project planning;
- ability to evaluate alternatives; and
- ability to work in teams.

These attributes are compiled from the answers to a survey completed by 200 of the leading companies in Europe in 1996 which asked: 'what skills do you want your new science graduates to have when you employ them?'. A lot of universities have recognised the importance of these skills and have taken actions to promote them.

Alumni often say that they forget the specific things they are told in university, but that the ideas and skills they acquire remain useful.

The relationship between knowledge and skill

A well-known Chinese proverb goes as follows. If you give a man a fish, you feed him for a day. If you teach a man fishing, you feed him for a lifetime. 'Fish' and 'fishing' are metaphors for 'knowledge' and 'lifelong learning skills' respectively. The knowledge about one course is 'small fish', knowledge about a discipline is 'big fish', and knowledge about the world is 'very big fish'. In different disciplines, the 'fish' are different, but 'fishing' is the same. Fish is the starting point for fishing, because students cannot learn 'fishing' without knowing about 'fish'. At different learning stages there should be different plans for knowledge and skills, as outlined in Table 1.

Table 1

Stage	General plan	Learning stage
1	knowledge	kindergarten; primary school
2	knowledge + skills	high school; university (undergraduate)
3	skills	university (postgraduate, PhD)
4	no teaching	workplace

Stage 1: In kindergarten or primary school students know little about the world, so 'fish' is the only possible choice.

Stage 2: In high school or undergraduate years, teachers teach both fish and fishing.

Stage 3: Postgraduate students or PhD students learn fishing and practice fishing by doing research.

Stage 4: There is no teacher in the workplace. Learners must learn independently and gain new knowledge and improve their skills.

Developing lifelong learning skills in students

According to contemporary teaching and learning theories, learners have the final responsibility for their own learning; the university teacher's job is to assist students in constructing new meaning (King 2004). Meaningful teaching and learning must actively involve the learners. Things that really count for successful learning are: motivation in the learner; interest of the learner; relevance to the learner's profession and to the real world (King 2004) Contemporary theories argue that we must adopt student-centred approaches in teaching and learning. The so-called student-centred approach means that teachers should think about how the learners learn and make the students actively involved in the teaching process.

In most cases, a combination of several teaching strategies leads to good teaching outcomes. Teachers should work out which strategies are suitable for themselves, their students and their course content (Zhang 2003). Teacher-centred teaching does have some advantages in equipping students with knowledge and skills, but it is weak in developing such attributes as communication skills and teamwork abilities. Hence student-centred teaching approaches should be integrated into a teacher-centred teaching process.

Course description and teaching strategies analysis

Course description

Circuit Analysis is a compulsory course for Electrical, Control, Mechatronic, Communication and Computer Engineering at second year level. Figure 1 is a course map of *Circuit Analysis* illustrating the overall schema that students are expected to have at the end of semester. The course consists of 64 hours of lectures. Student enrollment is over 120 in one lecture theatre. Students learn about basic electronic components and basic circuit laws and theorems, and should gain the ability to analyse DC, AC and transient circuit.

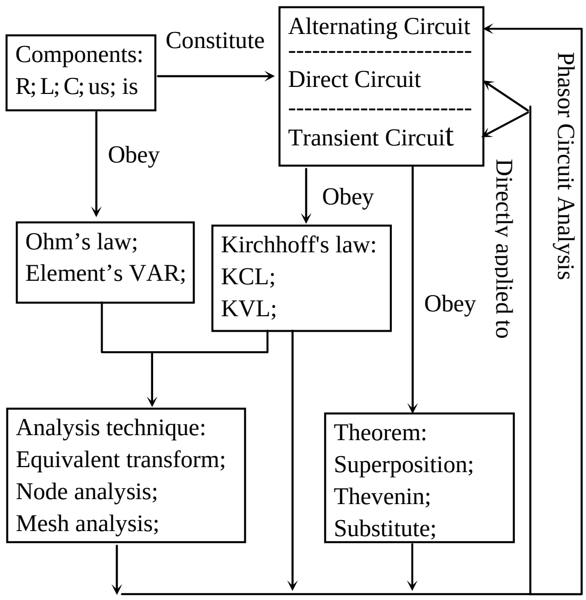

Figure 1. Course map of *Circuit Analysis*

Analysis of course teaching strategies

Though *Circuit Analysis* is a technique-intensive course, I try to minimise the abstract material and make the content relevant to the real world and to students. After first year students have the background knowledge of general physics and calculus, with little electronic experience, so problem based learning is not feasible in this course. However, problem solving skills and teamwork are especially important to future engineers. Hence the proposal is to keep useful ideas and good methods from traditional teaching strategies, whilst, incorporating some student-centred teaching strategies into formal lectures. Tutorials, interaction in the lecture theatre, case studies and reporting tasks, etc. will be integrated into *Circuit Analysis* to improve students' lifelong learning skills.

Positive aspects of my current teaching

I began to use multimedia instructional materials and *PowerPoint* slides in 1998. Students are exposed to *Pspice* and *Matlab* for electronic circuit analysis and design, which should be important skills for the industry. Students can easily access lecture notes and self-assessment quizzes from the campus intranet. The use of computer-aided instruction makes the content more interesting and visual. These are some the means by which knowledge is taught. At the same time I pay attention to cultivating students' skills.

Problem solving skills
Engineering is all about problem solving—specially by applying results from engineering research. One valuable part of my lecture is troubleshooting. The goal is to develop students' problem solving skills. The following is an example used in my lecture.

You are given one voltage meter and expected to determine which bulb in Figure 2 is damaged.

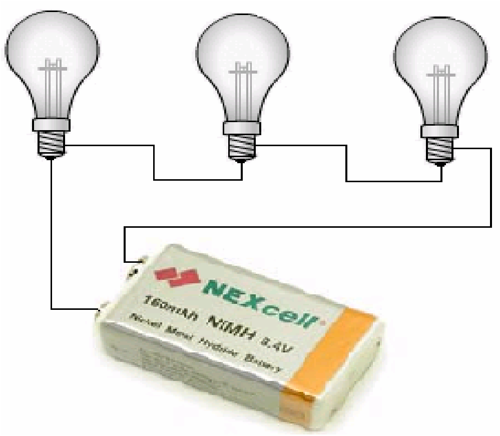

Figure 2. An example for trouble shooting

I want to address two points here. First, please notice that the problem is illustrated with Figure 2 instead of Figure 3, which is a circuit model. When circuit theories and general analysis techniques are introduced, abstract circuit models must be used. That is not a fault, many textbooks do not show how questions are related to real-world issues, since all the exercises are described using abstract circuit symbols. I try to bridge theory and application, with the consequence that students reflect that the course is relevant to engineering applications. The second point I want to address is that, trouble typically occurs in open or shorted components, or with components having wrong values. This knowledge comes from experience and engineers gain experience with practise. The circuit of Figure 2 becomes open when a bulb is damaged and 'open circuit' and 'short circuit' are two important concepts in *Circuit Analysis*. Only when students are familiar with the characteristics of an open circuit and consciously apply them to this problem can they find the answer. By doing this kind of troubleshooting, students gain engineering problem solving skills and experience.

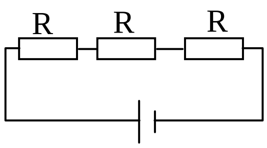

Figure 3. Circuit model

Lateral thinking skills
There are a variety of methods to determine voltages or currents in a given circuit and there are different ideas behind these methods. I often show students one solution and guide them to think of alternatives. Some alternatives are complicated, while some are simple. It doesn't matter. It is the thinking process and the associated thought processes that are important. Once I gave an example that could be solved in four different ways by using different theorems. They were as follows:

1 Thevenin + transposition theorem;
2 substitution + transposition theorem;
3 substitution + transposition + superposition theorem; and
4 design N_R network by KCL, KVL.

There are no separate disciplines in the real world. Those who can consciously apply multidisciplinary or interdisciplinary knowledge have more chance of success. *Circuit Analysis* is only a small stage for students to perform their skills, but I hope my students can develop lateral thinking skills and form the habit of applying multidisciplinary knowledge to solve problems through the training in the course.

Future modification

Group working tutorials
There is currently no special time for tutorials. Only a few students come to my office or email me asking questions. I usually spend one day per week marking assignments. This is obviously not an effective approach to teaching and learning. In order to change the situation tutorials will be added.

'Workshop Tutorial' classes are aimed at developing students' self-directed learning, teamwork and interpersonal skills (Sharma, Millar and Seth 1999). The classroom for tutorials should have movable desks and chairs. Each tutorial class should contain about 30 students and last one hour. The tutor will ask questions to guide students to think and to work together to determine potential solutions to a problem. Some questions will be challenging and relevant to real world, while some are from previous assignments. Students in each group are expected to work with each other, to share their ideas, to discuss, and to debate and convince each other, thus creating an active and interactive learning environment. One student in each group will be asked to give a short presentation to the whole class.

Interaction in lectures
Whatever the similarities and differences in learning styles and intelligence among our students, we can help all of our students by employing a range of active learning approaches (talking and listening, writing, reading, reflecting) and by using varied teaching techniques and strategies (Committee on Undergraduate Science Education 1997). Students retain 10% of what they read; 26% of what they hear; 30% of what they see; 50% of what they hear and see; 70% of what they say; and 90% of what they say as they are doing something (Lagowski 1990). This shows that we should let students say and do something.

During lectures, I will give students the opportunity to think and talk. I'll set some times during a lecture for asking questions or encouraging students to answer and ask questions. In this way I can assess students understanding and make them engage with the activity. I will also introduce hardware demonstrations in lectures. Although software demonstrations are cheap and convenient, it is a virtual world. When doing demonstrations I will let students predict what will happen next, and ask them to observe things going on and explain the theory behind it. Some questions may follow, to make the students learn interactively and to establish connections between pre-existing knowledge and new information. In this way students are expected to develop observational skills and thinking skills.

Other activities

I plan to use two or three case studies in the course. Case studies tell a real and complete story, are usually interdisciplinary and set in a real-world context, and have academic and professional significance and social implications. With case studies students can develop problem solving skills, skills for seeking and assessing information and interdisciplinary knowledge.

Students should be taught according to their aptitude. I will give excellent students additional training. For example, a few exemplary students will be encouraged to give mini lectures to review material, or on less important sections. Thus they will develop oral and leadership skills from the process of searching for information and inquiring about their classmates' understanding.

Summary

Teachers must consider the features of their courses and the characteristics of their learners before they think about what kinds of knowledge and skills students will learn from the courses. Then they must decide which teaching strategies are suited to their courses. My plan is to firmly carry forward good aspects of my previous teaching and incorporate contemporary teaching strategies to create a more student-centred teaching and learning climate for developing students' lifelong learning skills. Students are expected to develop problem solving skills, lateral thinking skills, teamwork ability, self-directed learning skills and communication skills in the course of *Circuit Analysis*.

Teaching and learning is a cooperative process between teachers and students. Before I try to teach in a different way I will introduce students to the new teaching and learning theory. I also need to seek colleagues' support and funds to implement appropriate changes. The work will be challenging and time-consuming. Hopefully, opportunities will coexist with challenges. I will constantly motivate myself in pursuing quality teaching.

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