

# Employing a combination of teaching approaches to improve the quality of teaching and learning

Lu Guizhu

Department of Electronic  
Engineering  
Xiamen University  
Xiamen City  
Fujian Province 361005  
People's Republic of China

## Abstract

In this paper, using the course *Digital Integrated Circuit Design* as an example, the author discusses how the introduction of some current teaching methodologies might be used to improve the quality of teaching and learning. Different models of teaching and learning suggest that the best strategy is to use a variety of teaching approaches in different courses and even in different stages of same course. Feedback from the employment market is one way, and perhaps the best way, to determine the quality of the teaching and learning. In addition to employing current teaching approaches, the curriculum program should be designed to ensure a high quality of teaching and learning.

## Introduction

The author was nominated by Xiamen University to take part in *Teaching Science in English*, a professional development program being conducted at the University of Sydney for Chinese university science teachers. It is a collaborative project between the University and the China Scholarship Council. After several months of coursework and observing lectures, laboratories and tutorials, the author has learnt a great deal about improving the quality of undergraduate teaching by adopting new teaching models and using new technologies in tertiary teaching.

Based on the review of several current teaching approaches, the author focuses on how to use these new teaching approaches to improve the quality of teaching and learning in a general course on electronic circuit design. Because courses in electronic circuit design have unique characteristics, the effectiveness of the teaching approaches discussed has significant impact on these courses? Are there any teaching approaches that would prove more effective in these courses? These are some of the issues that are address in this paper.

## Current teaching approaches

In the past, lectures have been the most popular and widely used method of teaching. Certainly, with a good lecture, students learn. However, research conducted in the early 1970s into learners' ability to retain information showed that learners retain only 20% of what they hear (Center for the Advancement of Teaching and Learning), and the longer a learner has to listen, the content remembered diminishes. It seems that lecturing only is not sufficient if you want to improve the quality of teaching and learning. Innovative experimental work has resulted in the formulation of a number of teaching and learning approaches e.g. problem based learning (PBL), case study, concept mapping and e-learning. These approaches have one common feature: the teaching and learning is student-centred.

These 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. The major emphasis is that the students must be actively involved in the learning process. However, from a pedagogical point of view, the teaching and learning activities should be structured in such a way as to activate the learner's own prior conceptions and relate them to the new knowledge. Accordingly, the learning environment should therefore provide the learner with opportunities to test and try out the new conceptual understanding in various applied circumstances (Järvelä and Niewivirta, 1999). It may be difficult for the teacher to effectively introduce new approaches into his/her teaching strategies especially when different course has different characteristics, but general teaching approaches could be used. How to use these teaching approaches properly in individual course is a big challenge for every university teacher. In this paper, the author takes *Digital*

*Integrated Circuit Design* course as an example to illustrate some appropriate models to apply in a general electronic circuit design courses.

## Introduction to the *Digital Integrated Circuit Design* course

The goal of *Digital Integrated Circuit Design* (Digital IC Design) is to introduce digital integrated circuit chip design, layout and electrical performance analysis to the students. This is a hands-on practical course with the use of simple, intuitive theory (University of Portland). Students will use VLSI design, layout and analysis Computer Aided Design (CAD) tools, specifically: *Cadence* and *SPICE*. At the end of this course, students should: appreciate the concepts of IC design and the different design entry approaches, identify circuit structures using digital CMOS technology, identify and analyse a number of basic circuit blocks, appreciate the different IC technologies and where they are used, realize the construction of *SPICE* circuit descriptions, etc.

Students need more practice and more practical applications in learning IC Design. Usually, a one-hour lecture should be supported by at least one-hour experimentation, but also students are required to practice after class. In order to improve students' motivation and interest in learning, the teacher should explain the purpose and application of the course. Teaching and learning approaches, such as problem based learning or case studies, may be appropriate and important ways of improving student interest and motivation.

IC design technology is developing rapidly. For example, Intel® announced that by 2005, they would produce chips with 1 billion transistors. According to Moore's Law, the number of transistors on a given chip will double every two years. Since IC design technology has been getting, and will get, more advanced and more complicated, learning for IC design needs lifelong learning skills. How to promote lifelong learning skills in students for professional advancement becomes the key feature of the teaching approaches in this course.

## Application of PBL in *Digital IC Design*

### Why PBL

PBL is a learning environment in which learning is driven by a posed problem in which the learner is interested in solving (Illinois Mathematics and Science Academy). The problems are based on real life, open-ended situations because teaching and learning in science should be made more relevant to the life of the students and as close as possible to a real professional experience (King, 2005). An important result of PBL is that while problems are used to identify what to learn, the process of learning 'how to learn' is also developed. PBL begins with a relevant real-life problem. Although the problem may not be solvable, it covers most of the course knowledge. Students can learn much by engaging in the process. The problem has been chosen to help develop skills important for success both in

the students' undergraduate education and in their professional life following graduation.

The rate of generation of new information in IT technology is truly staggering. Information becomes outdated rapidly and is updated constantly; much of what will be needed to be known in the workplace following graduation has not been generated yet! Thus identifying when new information is needed, where to find it, how to analyse it, and how to communicate it effectively are essential skills to learn in college. PBL really is effective learning, it is much more than memorising information to answer questions in examinations.

*Electronic circuit design* courses rely heavily on PBL with students working collaboratively in groups to solve real-world problems. Students learn to apply simple design concepts, find and evaluate design information, and communicate ideas about design techniques. PBL is helpful for students to combine the knowledge of different disciplines, which can open students' minds. PBL with teacher-led discussions, plus supplementary lectures, help to give a contextual and conceptual framework to the problems.

### How to implement PBL

From the above discussion, we may conclude that problem based learning is the most effective approach to promote students' lifelong learning skills. The following is a very good example of how PBL is used in The University of Sydney in a *Digital IC Design* course.

The course is for fourth year students and contains of 26 hours of lectures and 26 hours of laboratory design work (Jin, 2005). The objectives of this course are:

1. learn the foundations of modern CMOS digital IC design;
2. design a small, custom digital IC; and
3. learn to use state-of-the-art *Cadence* design tools.

There are three assessment components:

- |                           |     |
|---------------------------|-----|
| 1. laboratory design work | 70% |
| 2. final examination      | 25% |
| 3. class participation    | 5%  |

### The problem

Students are asked to *design and implement a GPS (Global Positioning System) satellite searcher* by the end of the course. The GPS satellite searcher provides a single output value that indicates the degree of correlation between the received signal and the C/A code for the appropriate satellite. In order to promote students' motivation, the teacher (Jin, 2005) even offered a \$200 CARlab IC design prize for the best design.

As shown in Figure 1, the three primary components required for a satellite search engine for the GPS are:

1. a C/A code generator;
2. a synchronous counter; and
3. an accumulator.

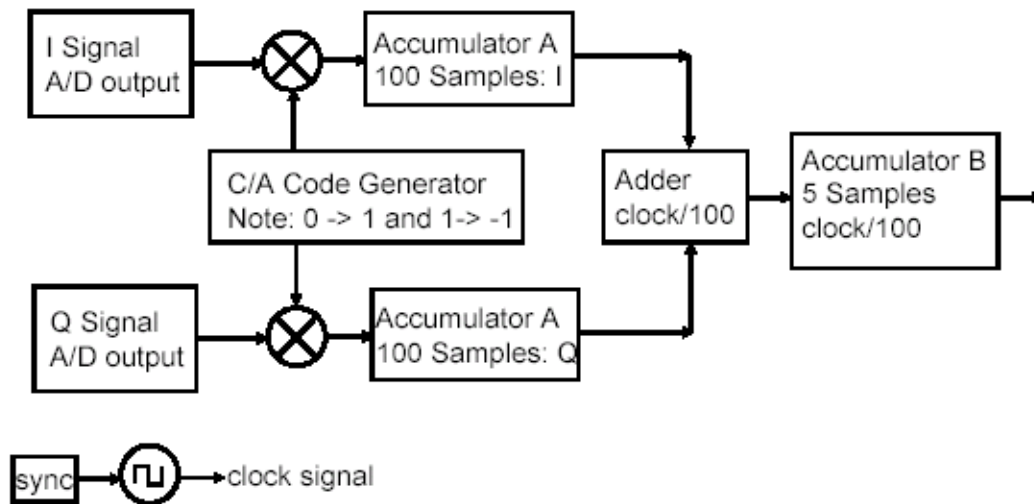


Figure 1. GPS satellite searcher implementation (Rinder and Bertelsen, 2004)

Students should make design decisions that optimise the power-delay product, e.g. their design should be for a hand-held (battery operated) GPS unit. So students must have some basic knowledge about how to design an optimised adder, counter, multiply and even shift register, since different structure of these devices have different performance. Obviously, it is impossible for the students to master so much knowledge in one course. There is another course, *Digital System Design*, for the third grade students at The University of Sydney in which students are asked to *design and test a 4-bit Computer*. In fact a third grade student majoring in Electronic Engineering knows almost nothing about how to design a 4-bit computer. Students begin from those basic elements: adder, register and multiply etc. For all of these elements, the students are shown many types of models one by one. Students learn them as a case study. As an example, for an adder, students learn at least two types of adders: a ripple carry adder and a carry-lookahead adder, which have different speed and performance.

From this example we see that for a design course, students should construct new knowledge on the basis of their prior knowledge and experiences. This means that students must have the ability to self-regulate learning. As discussed above, without a previous *Digital System Design* course, it is very difficult for the students to learn the concepts in the *Digital IC design* course. In the program at The University of Sydney, the curriculum is well connected. Another very important aspect is that modern IC design technology is developing very quickly and it is necessary for a designer to develop a life-long learning skill. In the mean time, modern IC design technology covers a wide range of areas and individuals can do very little without cooperation with others. In order to benefit the students' later professional work, teachers should include activities to promote their life-long learning skill and interpersonal skills. Without a specific learning environment and essential training, it is very hard for students to acquire these skills.

## National Undergraduate Electronic Design Contest

Following is an example of how to improve students with above average ability by a special teaching approach in China. The first National Undergraduate Electronic Design Contest (NUEDC) was conducted in 1994 in mainland China. The contest is organised jointly by the Higher Education Department of the Ministry of Education and the Personnel Department of the Ministry of Information Industry. The contest is held on alternate years, and in 2003 involved more than 400 universities and 9,000 students. The contest aims at advancing the all-round quality of teaching and learning in Chinese universities. This includes the improvement and updating of both approaches to teaching and course content. It also seeks to promote students' creativity or inventiveness and team spirit, as well as a wide range of skills in electronic design and engineering.

The NUEDC has its own unique characteristics. In allowing teachers the chance to closely observe their students at work and thus identify any remaining weaknesses in the students' abilities or gaps in their knowledge, the contest aids the process of teaching reform and the improvement of course quality and structure. As part of the pre-contest preparation, students receive after-school specialist training including use of equipment, and circuit design. In order to thoroughly appraise their abilities, students are assessed in both theoretical analysis and practical design.

The contest places great emphasis on developing collaboration or team spirit in all participants. The contestants are required to finish their compulsory design programs within four days to compete for the prize. Each team must consist of three students. Teammates are compelled to work cooperatively and collaboratively in order to accomplish the tasks within the four days allowed.

Participation in the contest not only helps individual students to identify their specific talents, but it is also attractive to prospective employers, benefiting students in

their later professional work. Past years have shown that the top prizewinners are not necessarily the students with the highest test scores at university. The contest offers a unique opportunity for students to show their abilities. It is quite a different assessment task compared with traditional the written examinations.

Although NUEDC has so many advantages, it is a special teaching approach, which is only used as an accessory to the teaching process in China. Furthermore, it only aimed to the third grade students and those students must have basic knowledge about circuit design.

## Discussion

Although this paper has mainly discussed the teaching process of *Digital IC Design*, the author's genuine purpose is to search for appropriate and effective teaching approaches of electronic circuit design courses in China in general. For Chinese university students, one big challenge is language. Almost all of those manuals, tools, software and even textbooks are written in English. Usually Chinese is spoken in class, however due to the technical nature of the terms and concepts met on the computer during the design experiment, they are all in English. It is hard for them to switch between Chinese and English, especially when these terms and concepts are quite unfamiliar even in Chinese. So the introduction of bilingual (Chinese and English) class mode into these courses is very important. As discussed above, electronic circuit design courses have their unique characteristics and need a large amount of practice. Traditional teaching modes, lectures plus written examination, is no longer effective. The new teaching approaches, such as PBL and case study should be applied in the teaching process of every electronic design course. At the end of the program of study, it may be better if there is was integrated assessment task to promote students' total learning skills, such as the NUEDC outlined above.

## Conclusion

There are a number of teaching approaches discussed above. There is not one superior teaching approach, and teaching approaches are not exclusive of one another. Different course have different characteristics, the best strategy is to use a combination of different teaching approaches in different courses and even in different stages of same courses.

Feedback from the employment market is one way to attest the quality of teaching and learning. Traditional written examinations only test how much students can memorise,

but in a design course, memory is irrelevant. Students are able to reference many design manuals, rules and data.

As well as teaching approaches, the program's curriculum is also very important and it should be highly organised. One important aspect is the attitudes of senior management, both at institutional and departmental levels.

## Acknowledgements

As a visiting scholar, I have found only generosity from the China Scholarship Council of the Ministry of Education to support my study, and I am grateful to Australia for providing me with a place at the University of Sydney to undertake my learning. Then there are those lectures, discussions and seminars that changed a stale environment into an invigorating one, full of humour and warmth. Especially thanks to Associate Professors Mike King and Mary Peat. Thanks to Dr JG Rathmell, Dr Craig Jin, Professor Ron Johnston, Professor Godfrey Lucas and Dr Rafael Calvo, my mentor, it would have been impossible to finish this paper without their aid and encouragement. The last but not least, thanks to Cecilia, Kathy, Nicole, and all my dear colleagues and friends meet in Australia, for all of those happy times together.

## Reference

- Center for the Advancement of Teaching and Learning, Kansas State University *What we know about the learning process* [Online] Available: <http://www.ksu.edu/catl/lprocs.htm>.
- Illinois Mathematics and Science Academy (2001) *Problem-Based Learning Network @ IMSA* [Online] Available: <http://www2.imsa.edu/programs/pbl/problem.html>.
- Järvelä, S. and Niewiurta, M. (1999) The changes in learning theory and the topicality of the recent research on motivation. *Research Dialogue in Learning and Instruction*, **1**, 57-65.
- Jin, C. (2005) *ELEC5402 Digital IC Design* course outline. The University of Sydney.
- King, M. (2005) *Lecture Notes: Teaching Science in English*. The University of Sydney.
- National Undergraduate Electronic Design Contest [Online] Available: <http://www.nuedc.com.cn/>.
- Rinder, P. and Bertelsen, N. (2004) *Design of a single frequency GPS software receiver*. [Online] Available: [http://kom.aau.dk/~rinder/AAU\\_software\\_receiver.pdf](http://kom.aau.dk/~rinder/AAU_software_receiver.pdf).
- University of Portland (2005) Introduction to Digital VLSI Design EE438/538 Course Syllabus. [Online] Available: <http://www.egr.up.edu/contrib/oster/ee438/syl.pdf>.