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Reform of experiment-based teaching of electronics

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ABSTRACT: An experiment-based course is compulsory for students in electronics. It is important in developing the student's practical ability skills, and in enhancing the student's overall engineering capacity for practising the profession. Existing problems with the teaching by experiment of electronics at colleges and universities were examined in this study, taking into account the author's own experience. The necessity and significance of reforming the teaching of electronic experiments were examined as well, and reform measures are proposed. The reforms aim to enhance students' practical abilities and skills, as well as their performance in engineering practice.

INTRODUCTION

The quality of students in electronics courses depends largely on their practical abilities and skills. Therefore, it is important to investigate how to strengthen experiment-based teaching to improve students' practical abilities and, hence, the quality of their engineering education [1]. Given the rapid development of technology and the demand for skilled engineers, colleges and universities should aim to produce adaptive, innovative graduates, with broad engineering knowledge, skills and attitudes [2][3]. To respond to this demand, colleges and universities need to reform the teaching of experiments in electronics.

Experiment-based teaching is the basis for developing engineering skills and knowledge. Through experiments, students connect practical ability with theory because they are testing the theory, and also applying the theoretical knowledge to guide engineering practice [4]. However, the present experiment-based teaching in electronics narrowly emphasises experiments to test theory and circuit programming, and this is inadequate. Hence, the urgent need to reform the experiment-based teaching of electronics.

PRESENT SITUATION OF EXPERIMENT-BASED TEACHING OF ELECTRONICS

Types of Experiments

Experiments include validation of the theory, the design itself and more comprehensive areas of the theory. The experiments are closely related to the theoretical content of the course. Some teachers of the experiment-based classes fear students do not understand the basic theory behind an experiment or are afraid students cannot finish the experiment within the specified time. As a result, they use nearly half or more of the time teaching the experiment, rendering it more likely the students will not complete it within the allocated time. The students are not expected to think independently and simply follow the instructions for doing the experiment.

Although the number of comprehensive and design experiments are increasing in experiment-based courses, the vast majority are confirmatory and testing experiments, i.e. validation ones. In addition, teachers want students to complete the experiment within the specified time, so they subconsciously reduce the requirements. For example, the teacher may connect-up a complicated circuit, and only require students to make simple modifications and measurements to it.

Hardware Experiment becomes a Software Experiment

With the development of EDA (electronic design automation) technology and programmable devices, circuit design, which was once a pure hardware exercise, has become a software experiment. But, no matter how good the simulation software, there is a difference between the software model and the actual device. The actual circuit will have many practical engineering problems, which software cannot simulate. Therefore, in teaching EDA software, its application range, advantages and disadvantages should be discussed, else the losses of using EDA outweigh the gains.

Inadequate Equipment for Use in Experiments

Most colleges and universities select experiment boxes that offer a variety of basic capabilities. These are adequate for basic validation and basic design experiments, but otherwise are limited. Due to the high cost of more advanced equipment, which also requires expensive maintenance, it is not widely used. This limits support for improved and comprehensive experiments.

Student Motivation for Doing Experiments

The author investigated the motivations of undergraduates doing experiment-based classes for electronics courses. The results showed that 61% of the students just wished to obtain the corresponding credits; 35% of the students wished to improve their practical abilities; and 4% of the students had no aim, i.e. they did not see the role of this course in their future work, which is similar to findings by Yang and Zhang [5].

Experimental work does not receive many credits in most colleges and universities and, as a result, students do not pay much attention to it and they do extremely simple experiments. Also, teachers' interest is not great and they do not give proper guidance to students.

MEASURES FOR REFORMING THE EXPERIMENT-BASED TEACHING OF ELECTRONICS

Understanding the Nature of, and Objectives of, Experiment-based Teaching

Many electronics graduates will become engineers in companies. Experiment-based teaching is the fundamental way to improve the practical engineering abilities of such graduates. Through experiment-based teaching, students can master the design, development and debugging of circuits. This improves their hands-on practical engineering abilities and puts them in an advantageous position for future employment.

The reform of experiment-based teaching should have the goal of enhancing students' practical abilities. The teaching should be student-centred, with the emphasis on student-learning rather than teachers' teaching. Teachers should focus on teaching methods and teaching principles, rather than detailed experimental procedures. Students should have more opportunities to innovate, with the problems left to them to solve. Teachers should use heuristics and problem-solving, including discussion to foster students' thinking about engineering.

Carefully Crafted Experiment Content

Teachers should understand the importance of experiments in developing students' practical abilities and engineering knowledge. High standards and strict requirements should be set, but these should still allow students to complete experiments within the specified time. Circuit design and comprehensive experiments should not simply consider the selection of objects to form a complex electronic system. Also, the content of experiments needs to reflect the different grades of students and their different knowledge and practical abilities.

Experiment teachers must design the experimental content to relate to theory and closely link it to engineering practice. The experiment contents should be realistic and interesting to students. Most students should be able to complete the experiment so as to provide them with a sense of achievement [6]. The key to selecting the content of experiments is to make clear the requirements, methodology, the knowledge to be consolidated by the student, and how the experiment improves the student's practical ability.

Teaching Concisely and Appropriately

The theory required by an experiment will have been taught before the experiment class. Teachers in the experiment class should focus on the content of the experiment rather than the theory. This leaves more thinking time for students, with teachers focusing on guidance. The teacher should respond to problems encountered by the students, with a discussion linking theory and practice [7]. Due to differences in the practical abilities of students, a disparate range of problems will be raised by students in an experiment. The teacher can heuristically guide the students using the teacher's knowledge to help analyse and solve problems and, hence, expand and accumulate practical engineering experience.

Strengthening the Connection between the Experiment-based Courses

At present, in the experiment-based teaching of electronics, each component course is treated independently of one another, rather than being treated as the organic whole that it is. Each teacher deals with the teaching in their own way, and some experiment teaching is not covered [8][9]. The relationship between the components of an experiment-based course is shown in Figure 1.

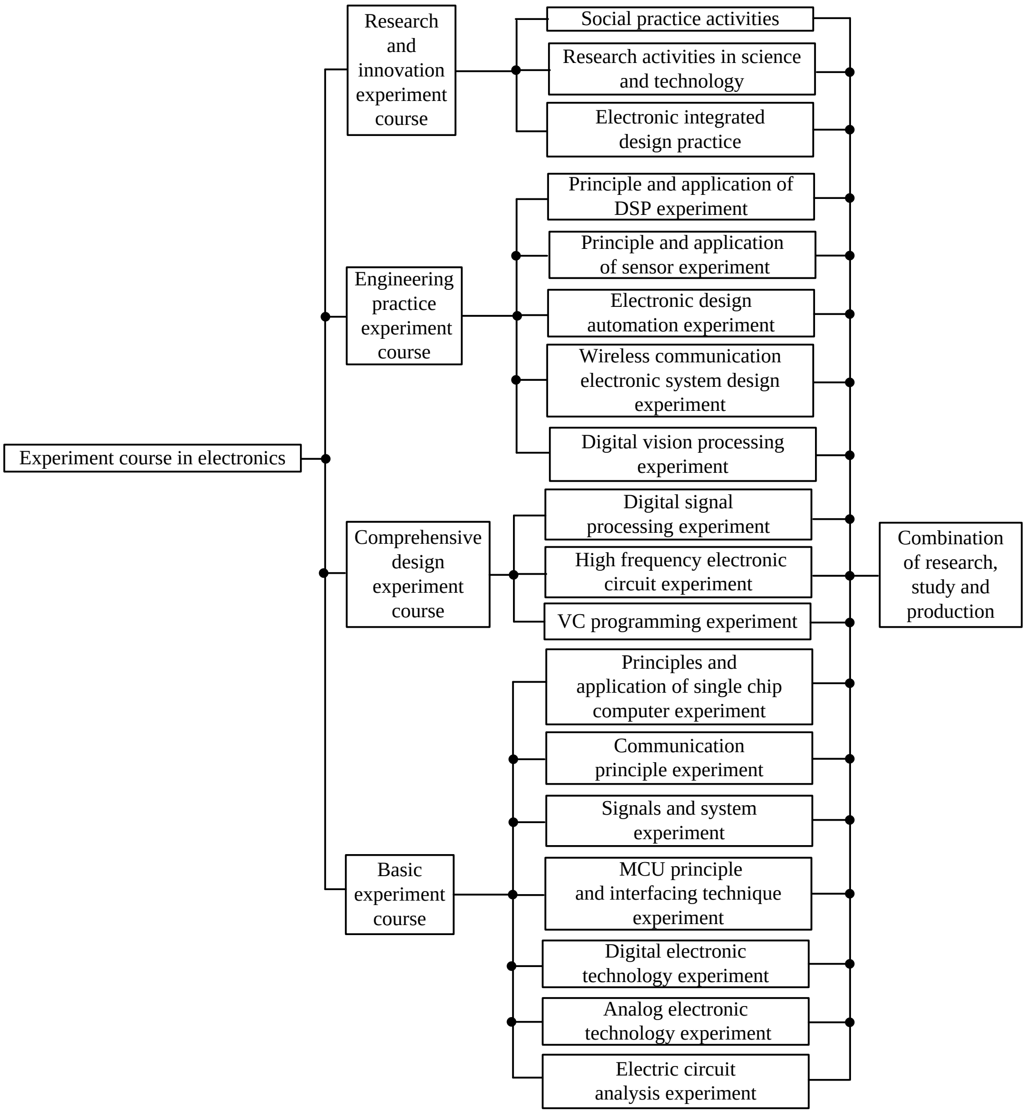

Figure 1: The relationship between experiment-based courses in electronics.

A complete curriculum system for experiment-based teaching should be formulated, with the teachers setting goals for experiments and practical teaching. Each experiment-based course should be considered and arranged in relation to the other courses. A course should consider the preceding and following courses. The experiment curriculum should proceed from shallow to deep, with a connecting link between the preceding and following courses. Hence, the courses should be mutually supportive.

It may be possible for a comprehensive experiment or project to cover a number of experiment-based courses. In this way, experiment-based courses can be linked together organically. As a result, students' interest in learning can be stimulated and the teaching improved.

Make Full Use of Modern Teaching Methods

At present, multimedia and animation teaching are widely used. It would improve the teaching of electronic circuits, if such teaching methods could be flexibly used [10]. The use of simulation demonstrations of electronic circuits using, for example, EWB (electronic workbench) or Proteus, provides a visual display of voltages and currents at various points in the circuit. The display, together with a teacher's explanation, greatly enhances the teaching. For example, in the TTL (transistor-transistor-logic) inverter experiment, the virtual instrument is simulated by the EWB software, measurements are taken and recorded and, then, compared with the theoretical data [11][12].

Simulation results of low-level input are shown in Figure 2; whereas simulation results of high-level input are shown in Figure 3. The simulations allow a student to determine visually the output voltage and the input voltage. Through such intuitive teaching methods, students' interest in learning is improved, and the relation of practical to theoretical knowledge is deepened.

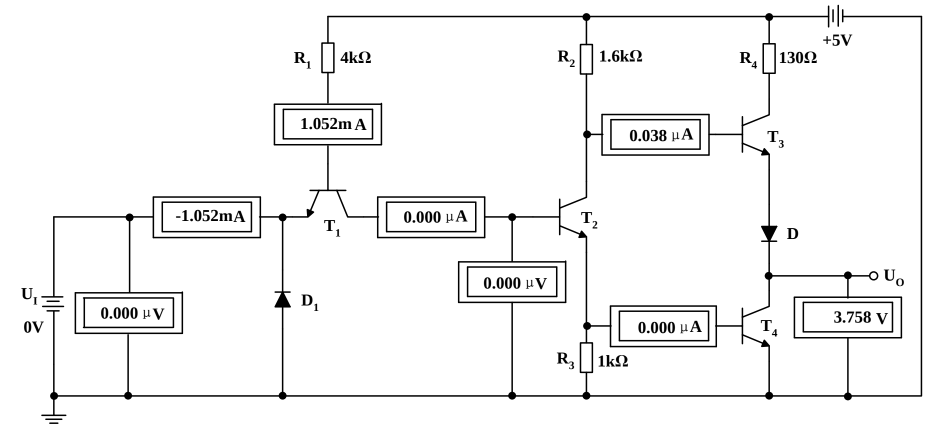

Figure 2: Simulation results of low-level input.

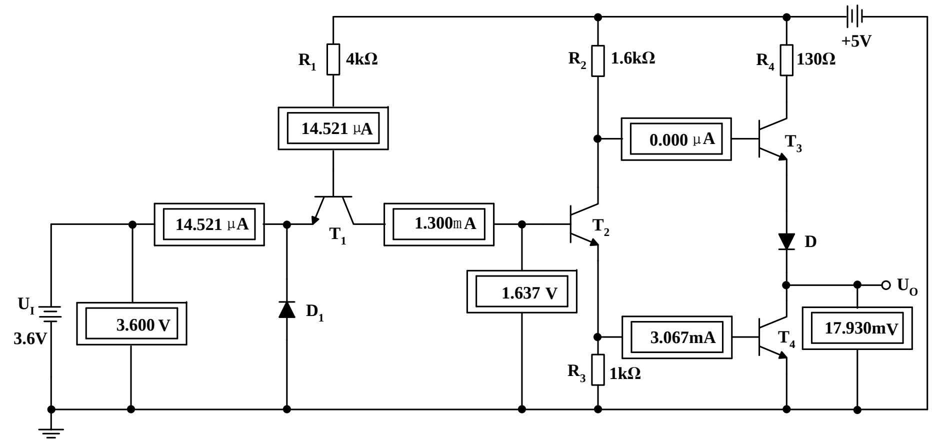

Figure 3: Simulation results of high-level input.

Appropriate Assessment and Examination

The experiment-based teaching should be assessed based on preview reports of the experiments, performance during the experiments and an experiment examination. The report of the experiment is important for students reviewing the experiment and processing data. The evaluation of students' performance should be as objective as possible. The teaching can be evaluated by studying student performance and attitude, and the teaching method. Appropriate assessment is important in improving teaching and enhancing students' interest in subsequent experiments. In the past, students have not fully and properly prepared the experiments. If preview reports are allowed into the examination, students will be greatly encouraged to preview experiments.

The students' performance during the experiments should be the largest component of the assessment. The performance result is derived from how well the student conducted the experiment, taking account of how much was independent and how much assistance was required. Attendance and attitude is also taken into account. The aim of the experiment examination is to promote study resulting from the pressure of a pending examination. The experiment examination is based on the operation of an experiment, gathering data and taking measurements.

EFFECT OF REFORMING THE TEACHING OF ELECTRONIC EXPERIMENTS

Table 1 lists the effect of teaching, from 2009 to 2013. Reforms of the teaching of experiments were introduced from 2012 and extended in 2013.

Table 1: Effect of reformed teaching.

Time (Year)	Students' assessment of experiments	Experiment curriculum	Examination method	Students' engineering quality
2009	Not interesting	Deficient	Experiment reports	Very low
2010	Not interesting	Deficient	Experiment reports	Low
2011	Somewhat interesting	Deficient	Experiment reports	Medium
2012	Good	Very good	Experiment report and performance in experiments	Medium
2013	Very good	Very good	Experiment report, performance in experiments and examination	High

In recent years, the teaching of electronics experiments has been reformed. The curriculum and assessment have been changed, leading to improvements in teaching quality, as well as students' practical abilities and mastery of experimental methods. Students are better able to combine theory with practice and have an enhanced interest in learning. Their sense of innovation and desire to solve problems has been greatly improved.

CONCLUSIONS

Experiment-based teaching must keep pace with technology and it also should be practical. The reform of experiment teaching in electronics is of great significance as a way to improve students' practical abilities and engineering quality.

Academic teachers should make clear the essence and goal of experiment teaching and optimise the curriculum so as to improve teaching by making full use of modern teaching methods. The reformed system should improve students' innovative product design and development abilities. The reforms also should cultivate better qualified and more creative engineering talent.

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