
Exploration of Experiment Teaching Reform Guided by the Engineering Education Philosophy

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Abstract

In order to make the electronic design contest and reform of experiment teaching to support and promote each other and improve students' practical and innovative ability, the paper analyzed the requirements on the students' ability of comprehensive knowledge application and practice by NUEDC, and the deficiencies of the depth and scope of electronic information professional practice curriculum. Use the issues-based, project-based and case-based engineering education philosophy and teaching methods as orientation. The way of practice teaching reform and the effect of the reform from six aspects are also discussed: the construction of hierarchy practice teaching system, the seminar and the optimizing of teaching content, the engineering teaching method, the experimental teaching environment and full control of network-assisted teaching platform.

Keywords: national undergraduate electronic design contest, practice teaching system reform, practice teaching content reform, engineering practice

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1. Introduction

In china, National Undergraduate Electronic Design Contest (NUEDC) [1] is co-sponsored by the Department of Higher Education of Ministry of Education and Ministry of Information Industry from the beginning of 1994, which is a biennial event. The purpose of the contest is to promote the construction of electronic information specialty courses in accordance with the principle of closely integrating of teaching practice, focusing on the foundation and advance. It also guide colleges and universities to focus on training the students' ability of innovate and the spirit of collaboration, strengthening the students' practice and engineering ability, improving students' ability of electronic design and assembly, attracting and encouraging students to participate in science and technology activities after class, and creating the conditions for outstanding talents. The number of schools and teams participating was on the rise every year. In 2011 there were 10,972 teams from 1,042 schools participated across the country. NUEDC is the longest-held, largest, most influential college students discipline contest in the field of China's electronic information [2].

Southeast University (SEU) had nine electronic information related departments, which organized students to participate in NUEDC each time. When the teams were expanded, to make the competition more effective on teaching and improve the students' practical ability, teamwork and a pioneering spirit, a lot of exploration and research work on college students' practice teaching system reform must to be done.

In the short paper, the way of practice teaching reform and the effect of the reform from six aspects are discussed: the construction of hierarchy practice teaching system, the seminar and the optimizing of teaching content, the engineering teaching method, the experimental teaching environment and full control of network-assisted teaching platform.

2. Phenomenon of the Current Situation

NUEDC is the integration of multiple disciplines. Its content related to multiple curriculums and courses like computer technology, electronic technology, control theory, sensor technology and communication technology. NUEDC held in early September of the contest years. The majority of participating students are the senior and junior. The contest

requires participating students in the time of four days and three nights to complete the process. The process is generally as follows: first topic selection, then inquiring information, followed by a rgument, hardware and software design, components selection, and assembly, finally tuning, testing and report writing.

All the topics of the contest were based on engineering background. The requirements were from practical projects, which need to not only complete specific functions, but also evaluate the pros and cons of performance. For the students, both the breadth and depth of knowledge involved, the integrated applying of multi-disciplinary knowledge and practical capability is very challenging [3]. The teaching requirements for students are far from being simply a course that can be satisfied [4]. It was needed to build practical teaching system combining the inner and outside class under the guidance of the engineering education philosophy.

The laboratory curriculum arrangement in general colleges were set up around the theory courses. No matter the theory and laboratory courses were scheduled together or separately, the main contents of experiments corresponded with the requirements of the theory courses. The biggest advantage of this arrangement was that the experiments verify the theory. It was good for understanding and mastering the relevant theoretical knowledge points, but the following problems were also presence:

Phenomenon 1:

Each curriculum carried out experiment teaching around the syllabus, which emphasizing the integrity and system of its own. The link between the curriculums was absence. The lack of the overall concept of the project made the lack of the integrated system design capabilities of students.

Phenomenon 2:

Many of the experiments were designed only to correspond with some point of knowledge and lacked of engineering background or practical value. Students could not understand the real meaning of the experimental data. And the concept of function of the project and performance indicators was not established. Experiment was far from the engineering. It was difficult to stimulate students' interest in learning. Students were also difficult to enjoy the fun of success.

Phenomenon 3:

Limited hours were assigned to a different course experiments. Each experiment emphasized its own basic requirements which are commonly 2 to 3 hours. It was difficult to set gradient for project in depth and difficulty. The students just glimpsed in the experiment, and were difficult to have space of improve.

Phenomenon 4:

With the rapid development of electronic technology, the update of basic experiment content was much slower than the development of new technology, devices and design methods. It is necessary to guide students in the experiment to independently study, query with the use of every kind of resources to achieve learning by doing and learning in research.

3. The Reform of Experiment Teaching

3.1. Building Hierarchical Experiment Teaching System

Using engineering education philosophy as a guide, the trainings of practical innovation ability are throughout the whole process of experiment teaching, building a teaching system consisting of a series of interrelated teaching activities. By learning the knowledge and training corresponding ability and following the principle of gradual and orderly progress, the leap which from accumulating of basic knowledge to the fusion of comprehensive knowledge and the capability of innovative would be made.

The entire capacity training was divided into three stages in specific implementation, as is shown in Figure 1.

Stage I: Engineering Practice Basic Training

The engineering practice basic training is the stage for the freshmen and sophomores. Following courses are involved: basic electric and electronic experiments, circuit experiments, digital circuit experiments, analog circuit experiments, and electric and electronic technology experiments. The purpose is to help students to establish learning objectives, stimulate learning

motivation and interest in learning and strengthen the basic skills of engineering and build platform of engineering practice for innovation.

Stage II: Practical Application of Engineering

This was based on adequate training in the first stage and for the sophomores and juniors. The courses corresponded were: PLD experiments, MCU experiments, embedded systems experiments, sensor application experiments, and the control technology experiments. The purpose is to train the students' ability to acquire new devices, technologies and method. The experiments focus on training students of design ability.

Stage III: Comprehensive Implementation of Engineering

For juniors and seniors, the corresponding courses are: digital system design and comprehensive electronic system design. The purpose is to teach students using of all kinds of knowledge flexibly, and train the students' innovation design abilities of project-oriented with engineering background. This could implement the leap of creative abilities from passive receiving to active discovery.

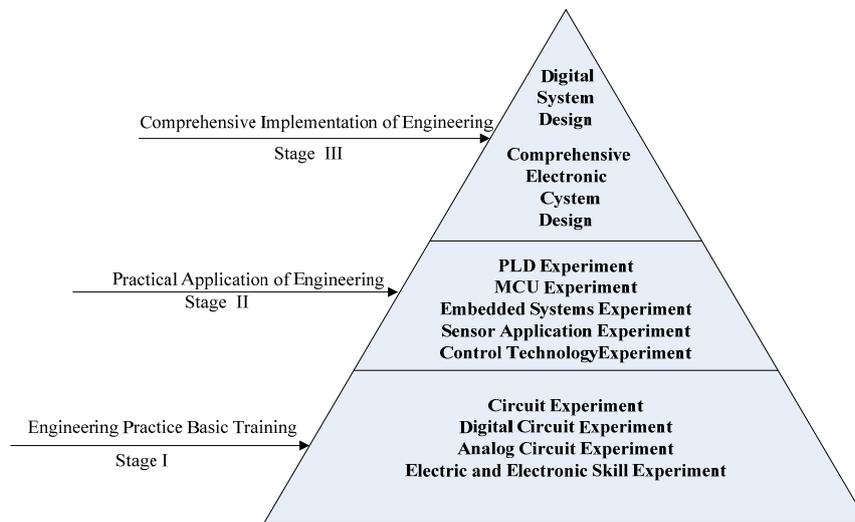


Figure 1. Three Stages on Capacity Training

3.2. Establishing Thematic Seminars

The content of previous NUEDC can be summarized into the following classes: electric power, radio, instrumentation, data acquisition and control. Relating knowledge was explained in the different courses. But due to the constraints of the time, professional background and students' interesting, further discussion was hard to be carried out in normal teaching schedule. At the same time of basic courses of electronic information, seminars in multi-level, multi-field and multi-directional were established: such as the analog signal conversion and processing, sensors and signal conditioning, small signal measurement, measurement and control circuit design, DC-DC transform and SOC design technology. Every seminar, apart from a brief theoretical knowledge, focused on the expansion of the design concept, design methods and new applications. By those experiments, students were guided to challenge some difficult issues in the professional areas.

The seminars trained students' ability at finding and solving the problem, and summing up experiences. This special teaching mode made the teachers and students have more opportunities of communication and discussion. Students could launch the relevant research topic and carry out the various NUEDC and students research projects. This developed students' scientific research ability.

3.3. Optimizing the content of experiment curriculum

Both the basic experiments and the seminars were always focusing on the cultivation of students' self-learning ability. Optimization of each content of curriculum gradually improved students' comprehensive design capability and application ability as well as mastering the basic

principles, concepts and practice skills. It created the conditions for extracurricular research and deeply carrying out of NUEDC.

Take the electronic circuit experiment as an example: lots of changes from the experiment teaching content were made. The original simple cell experiments were combined to several comprehensive experiments with engineering background such as the design of VGA, wave generator and audio power amplifier. These projects were organized on the way of engineering. This was for the training of the students' system design and engineering application capabilities. The contents of the experiments were divided into fundamental part, raised part and innovation part, in order to meet the requirements of students of different abilities, which also provided a good foundation for selecting students to participate in the NUEDC. Finally, the experimental methods, assessment methods, software and hardware environment were reformed correspondingly to stimulate the students' interest and motivation to learn, cultivate the students' teamwork spirit. Good result in teaching and learning has been appeared with the combination of theory and practice, basic and enhanced, unit and system, virtual and real, individual and teamwork and achievements and ability.

Take the project of waveform synthesis and decomposition as an example [5], showed in Figure 2. The project involved comprehensive electronic circuit knowledge. Normally the curriculum was arranged as several related experiments, such as sine wave generator, active filter and the adder circuit. Students were not clear about the connection between circuits during the experiment. After integrating these knowledge points as a project, the project proposed complete performance requirements. Each three students as a team were required to complete the project. They must discuss the following topics together: how to design the project, the assignment of responsibility and the schedule. Sometimes the unit circuit made by individual was accomplished, but the system composed by these units could not meet the requirement. This needed the whole team to analyze and solve problems. This project not only trained the system design ability of the students, but also paid more attention to reasonable cooperation between units and system design. It was also very good for culturing students' spirit of collaboration.

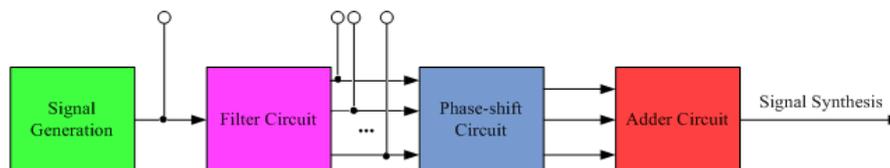


Figure 2. Signal Generation, Decomposition and Synthesis

The reform in electronic circuit experiment contents and methods has been made in the honor class of Wu Jianxiong College for 3 years. The students' comprehensive experimental ability and self-learning ability has been greatly improved. It has also been generally approved in the surveys of students.

3.4. Exploring the Engineering Teaching Method

Electronic information is a typical engineering discipline. The training of talents must meet the requirements of modern engineering. In the education reform process, it is necessary to strengthen the cultivation of engineering and make students learning about standard development process, and matching with the project as soon as possible. At the same time, we cultivated students' comprehensive awareness of project, abilities of system design and solving practical problems to enable students to keep up with the rapid development of new technology and new devices.

In the third stage of teaching system, students combine their interest in according disciplines direction and choose a practical application of engineering as experimental design project. The project accomplished after the process of design, circuit implementation, system debugging, checking and acceptance, summary and presentations.

Major requirements were placed on the process of design ideas and actual assembly, emphasizing the engineering practice content like the program analysis, system implementation, debugging and testing, reliability and project management. The implementation of those projects would involve a lot of related knowledge. It required students to master the knowledge and comprehensive application. Students' ability of writing, speaking and teamwork were trained through the usual discussions and seminars. Those also emphasized the culture of innovative thinking, knowledge utilization and engineering practice [6].

Take the experiment of electronic temperature regulator as an example, showed in Figure 3. The design purpose was to achieve fast, accurate and stable temperature control, and real-time display of the temperature inside the device. The basic process was first to convert the measured temperature into voltage signal by Peltire sensor. Then measure and display the voltage after the amplifier using ADC. The MCU controlled the closed loop depending on the temperature requirements. The project involves a multi-course knowledge, such as analog electronic, digital electronics, microcontroller and PLD. Every part of the unit experiments was done in the appropriate courses and was implemented in a variety of methods. Through the flexible application of knowledge, cell design, system integration and assembly, the actual production and the engineering practice capability of student was trained.

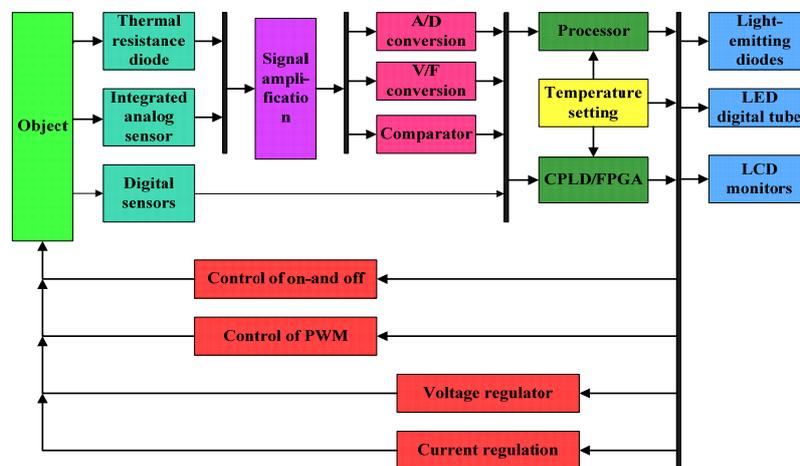


Figure 3. Electronic Temperature Regulator

3.5. Building Environment and Conditions to Adapt Research and Exploring Experiment Teaching

Experiment teaching cannot be separated from the experiment conditions. In accordance with the basic principles of synchronizing reform and construction, hardware and software, integrating advanced concepts and teaching techniques, the experiment center has designed and constructed the fully autonomous and innovation conditions for students to do scientific research and engineering practice using knowledge freely.

1) Integration of Experiment Conditions

For the characteristic of comprehensive opening, researching and innovative experiment teaching mode, the experiment center has developed the idea for laboratory construction, that is conducive to the students to give full play to the ingenuity, independent innovation practice, and conducive to improve the effectiveness of experiment teaching resources as laboratory space and equipment.

Experience of teaching and management which had been accumulated over the years has been integrated into the laboratory building programs. Experiment center also cooperated with other departments and international high-tech enterprises (TI, Schneider, Xilinx, Cypress, Altera, etc.). Thus, the lab has built comprehensive innovative practice teaching platform, so the students' innovative practice would not be affected by resource constraints. The platform fully met the hardware and software requirements for research, design, analysis, simulation, production, welding and testing.

2) Flexibility of Experiment Platform

To meet the requirements like resource-rich, state-of-the-art technology, open structure, safe and reliable, experiment center has independently developed series of electric and electronic experiment systems, such as integrated modular design training platform, Peltier temperature measurement and control devices, transmission control and measurement platform, electronic scale device and so on. Students could choose the experiment module according to the need of practice project, and build personalized platform to conduct the research and exploration. Experiment modules can be flexibly combined and reused for different courses, practical projects and extracurricular research and learning activities.

3.6. Construction of Full Control of Network-assisted Teaching Platform

In order to achieve comprehensive management of experiment teaching. Experiment Center has been exploring in recent years. After nearly two years of research, construction, implementation and perfection, the experiment center has designed management system with advanced educational philosophy as a guide and computer network as technique. The system consists of hardware and software [7-9].

The management system requires certain hardware to support it, such as the terminal equipment including instruments, data acquisition unit and computer, the management facilities including allocation terminal, power control adapter, power controller, PDA for experiment teaching and servers including Web server, streaming media server and laboratory management server. These hardware facilities are preconditions of the experiment management.

The software systems include curriculum requirements, electronic lesson plans, instructional videos, the device manual, design, application notes, software tools and practice cases. The teacher of the experiment center focused on building the personalized teaching aids and process management system, including experiment courses management, the process management, the practice project management, the examination management, survey management, and more.

The experiment course management: Course leader selects various types of experimental projects from the experimental project library, and set assessment methods and proportion of scores.

The experiment process management: The management is implemented with following aspects: students' preview and design, components selection, teachers' approval of experiment program, allocation in laboratory for students, experiment data and waveform acquisition, electronic lab report writing and submitting and teachers' marking of the report.

The experiment project management: For practical activities based on research, such as curriculum design, the extracurricular research and academic contest training, the management is achieved from following process: teachers publish project information, and then students submit a project application. After that teachers confirmed the project and students submit project confirmation and design documents. Finally students submit project summaries and demonstration video and teachers review and acceptance that.

The system has played a good role in carrying out the personalized student-centered open experiment teaching model.

4. Effectiveness of the Reform

Oriented on the problem, project and case-based engineering education philosophy and teaching methods, a complete hierarchical practice teaching system was built, a series of thematic seminars have been set up, several projects of engineering background and systemic experiment were carried on. After the reform of practice teaching methods and content, the students' interest and enthusiasm have been fully mobilized, and actively participate in various Electronic Design Contest and extra-curricular science and technology activities. The Electronic Design Contest and teaching reform mutually support and promote each other. The reform improved the quality of teaching, and also made excellent competition achievements and extra-curricular researches. In the 2011's NUEDC, 3 national first prize and six second prize were achieved by SEU, which had totally 42 teams participated. In 2012 NUEDC-analog electronic systems topics invitational tournament, there were 110 teams from 58 universities, most of which were national plan '985' and '211' universities like Tsinghua, Zhejiang University and

University of Electronic Science and Technology participated. Three teams from SEU achieved 2 first prizes and 1 second prize, from totally 11 first and 17 second prizes, which were the best results. More than 30 projects were accepted in the 2011 national and provincial undergraduate research training program. And 31 projects were accepted in SRTP (Student Research Training Program). At the same time, the electronic design contest, smart car competition, PLD contest, embedded systems and other competitions were also organized in the campus. Nearly 1000 students participated in those contests each year, which means 60%-70% of student learning electronic information. Students' capability in active learning and research has improved significantly. In 2011 electronic information professional students received a total of more than 20 national patents, and have published 25 research papers.

Students' self-learning ability and overall quality has significantly improved under the hierarchical practice teaching system. A lot of them were recommended to graduate school exemption. They showed obvious advantages in specialized courses learning, graduation design, graduate studies and development into the community. They also have been widely welcomed by employers and graduate instructors.

5. Conclusion

After several years of teaching reform, research and exploration, mutual support and promotion between NUEDC and practice teaching reform have been taking effect.

The hierarchical practice teaching system has been conducive to the students to break the course boundaries and strengthen the integration and use of knowledge. Gradual arrangement of the content of curriculum could gradually improve practice requirements. Thereby the low-level duplicated experiments have been reduced and efficiency has been improved. The use of the limited resources of hours has also been optimized.

By establishing thematic seminars of different disciplines and backgrounds, experiments and projects with new technologies, new knowledge and new device have been merged into the hierarchal practice teaching. This has led to the continuous training of the students' engineering capability of learning, query, expand knowledge, research and exploration, programs discuss, design simulation, system implementation, debugging and testing, analysis and summary and overall quality.

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