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Research and Practice of Optoelectronic Circuit Experiment Teaching Reform Based on Innovation Ability Training

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Abstract
One of the key tasks for higher education is to train innovative talents for the national construction and development, and experiment teaching is an essential part of the higher education. This paper explored the experiment teaching model of optoelectronic circuit from the perspectives of independence and comprehensiveness, integrated the innovative thinking training into the experiment courses, so as to further promote the innovation ability of college students. Through the reform attempts in the experiment teaching for students of three different grades, it was found that the students' innovative thinking has been fully trained, and innovation ability greatly improved. And this experiment teaching model provides a useful support for integrating the innovation education into teaching.

Key words: Optoelectronic circuit experiment; Experiment teaching; Innovative thinking; Innovation ability

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INTRODUCTION
It is important for innovation in leading the development of economy and society of China. Innovation-driven development strategy as a basic state policy will be an increasingly strategical support for the national development of the new era. For higher education, the most important tasks are to reform the innovation education model, enhance the implementation of innovation education, promote the innovation ability of students, and train creative talents for the national socioeconomic development and the construction of an innovation-oriented nation. In the whole process of higher education, training of students' innovative thinking and ability is mainly based on the theoretical teaching and practice teaching, and particularly practice teaching, because practicing helps initiate the innovative thinking and cultivate the innovation awareness. To cultivate and promote students' innovation ability, the course *Optoelectronic Circuit Design Experiment* is set up on the basis of the internal connection and logic of relevant courses, and the teaching model is reformed by adopting the "five changes and three integrations" to break the conventional experiment teaching dominated by textbooks, teaching aids and teachers, and fully develop the subjective initiative of students. Within the specified scope and difficulty of profession, students are encouraged to choose their own subjects and design by themselves, finally make differentiated works with practical functions. Such a teaching model encourages students to think actively and make innovative attempts, and enhances their innovative thinking and awareness.

1. CURRENT EXPERIMENT TEACHING
In terms of innovation ability training, most colleges and universities choose to organize innovation competitions by training a few talented students within a short term for the competition, but neglect the innovation ability training of the majority. Through experiment teaching, students learn basic experiment skills and improve their operational abilities, moreover, by analyzing the experiment process and results, they learn to figure out the problems and

give their own solutions, which will push them to think actively and explore new views and finally get new findings. It is the ultimate goal of experiment teaching in training students' innovative and creative abilities.

For science and engineering majors, practice education is required according to the current standards of the Ministry of Education. However, the experimental lessons are often affiliated to the theoretical teaching, and the teaching contents are most replication experiments with single forms. In most cases, the whole class shares the same task, and the experiment contents are fixed in a long term, and students are only taught to operate according to specific experiment theories, instruments, methods, procedures and record data in fixed formulas, while teachers play a dominant role in the whole teaching process, as a result, there are few opportunities for students to think and observe independently.

2. EXPERIMENT TEACHING IN INNOVATION EDUCATION

The traditional experiment teaching model fails to provide methods and contents for training students' innovation abilities and thinking, so it cannot meet the needs of innovative talent training. Considering the requirements of national development on innovation education, as well as our experience in teaching of theoretical lessons and experiment lessons, we carried out trial reforms in the experiment teaching in terms of innovation education, and made some achievements in the training of students' innovative thinking and promotion of their innovation abilities.

2.1 Independent Experiment Courses

Affiliated to theoretical courses, most traditional experiment courses are regarded as only a supplementary method for the intuitional teaching of theoretical knowledge, to help students understand and grasp the difficult theoretical knowledge, but neglect the training of students' innovation abilities and thinking. The independent experiment courses, based on the training of students' innovation abilities and thinking, should be goal-oriented and take "up to the expected requirements" as the standard for examination, but not confine students in the application of a certain theory, so students will be able to think and give solutions to possible problems actively, and their innovative thinking will be enhanced.

2.2 Comprehensive Experiment Courses

In most colleges and universities, teaching of different experiment courses is isolated even the science and engineering knowledge in these courses are highly connected, the isolated learning of a specific knowledge point will split the knowledge system, and students will not be able to comprehend the knowledge systematically. Therefore, a comprehensive experiment course is necessary for those courses with highly-related knowledge, so that students will be able to link the knowledge points of different courses, analyze and solve problems comprehensively and systematically, and their innovation abilities will be enhanced.

3. REFORM OF THE OPTOELECTRONIC CIRCUIT EXPERIMENT COURSES

Considering the university's requirements on innovative talent training, we reviewed and analyzed all knowledge points in such courses as *Analog Electronics Techniques*, *Digital Electronic Technique*, *Optoelectronic Technique*, *Principles of Microcomputer*, *Principle of Communication*, *Single-chip Microcomputer System and Development Technology*, then from the independent and comprehensive perspectives set up the comprehensive experiment course of *Optoelectronic Circuit Design Experiment*.

The experiment contents include the whole process from hardware circuit design to relevant software development. By applying the teaching method of "five changes and three integrations", the training of innovation awareness and abilities is integrated into the experiment teaching, and the reform attempts are made in terms of the experiment task selection, setting up experiment contents and student examination, so that students are able to get innovative thinking and self-innovation awareness, their innovation abilities will be enhanced.

3.1 Reform Contents

In the experiment teaching, "five changes and three integrations" is applied to reform the teaching method, among which "five changes" are specified as below.

Change of experiment contents. The static experiment contents are replaced by dynamic ones, for example, by following the new research focuses and learning from the latest research tasks and new cases in innovation contests, proper contents can be selected as the experiment tasks.

Change of experiment task selection. "One task for one class" model is replaced by "one task for one student" model. For traditional experiment courses, the whole class shares the same experiment task, and the experiment contents are fixed for a long term, which is suitable for only experiment teaching of basic theories. For the comprehensive innovative experiment course, students' abilities vary greatly, the traditional teaching method fails to cultivate students' innovative thinking and ability. So "one task for one student" mode is applied to encourage students to choose their favorite experiment task according to their own characteristics, enhance their curiosity and innovation awareness, and improve their innovative thinking.

Change of student examination and evaluation. The traditional uniform examination is replaced by

the differentiated examination focusing on students' innovative thinking and abilities. During the experiment teaching, some students have already participated or are participating in various scientific research or innovation projects, and they have better innovative thinking and operational abilities. Oversea Chinese descendents take up a large ratio of students in Jinan University, these students' thinking training and ability training must also be improved. In view of the differentiated individual capabilities, the student examination and evaluation has to be changed correspondingly. The comprehensive experiment course focuses on the following aspects of students in examination. ① If the student works as scheduled; ② Efficiency of work and execution; ③ Working attitude; ④ Ways of dealing with obstacles and difficulties; ⑤ Improvement of experiment ability; ⑥ Summary of course report, particularly feelings and experience and also self-examination in the experiment.

Change from teacher-dominated to student-dominated experiment model. The traditional teacher-dominated knowledge teaching process is replaced by the student-dominated self-directed learning process. Students are instructed by teachers to search literature, collect useful data, fulfill the deep processing of information to make them rational, logical and systematic, propose the primary project design. They are organized into many groups to communicate their designs, review the possible problems and figure out the optimal designs. In the implementation of projects, teachers can communicate with students as the organizer, collaborator and spectator in case of problems, they may give some help but not solve the problems directly for students. If it is too difficult for students, teachers are expected to analyze the difficulties and encourage students to solve the problems by themselves, hold on their own views, and enhance their innovative thinking, confidence and perseverance.

Change of teaching activities. The traditional singular experiment teaching activities are replaced by the teaching activities aided by modern education means. On the basis of conventional teaching activities, modern education techniques and means are integrated to broaden the teaching activities in terms of both time and space. The modern education techniques include, ① Virtual simulation technology can be applied to demonstrate the feasibility of project before implementation, help students to figure out, analyze and solve problems, encourage students' creative activities; the virtual simulation practice platform can be used to give diversified solutions to the problems and difficulties in the project implementation, initiate students' divergent thinking and thinking potentials. ② Modern network technology enables students to share resources without being confined by time and space, communicate with teachers conveniently, learn and think independently, further enhances their creative spirits and practical abilities and also the ability of acquiring knowledge actively.

"Three integrations" include the following aspects.

Integration of in-class and out-of-class time: teachers' instruction and students' communication in class, data collection, communication and feedback for problems out of the class will co-promote students' independent learning and thinking.

Integration with scientific research tasks: based on the requirements of syllabus, latest research projects and successful cases in innovation competitions can be integrated into the experiment teaching.

Integration with modern network technology: network communication is a kind of extension and aid for the face-to-face communication in class, students' feedback out of class will in turn help teachers to make teaching plans with pertinent objectives, and further enhance students' creative thinking.

3.2 Implementation Methods

The implementation of experiment course can be divided into four sections, namely project preparation, project importing, project implementation and project completion.

(a) Project preparation

Teachers play a dominant role in selecting the tasks and contents of experiment courses, following the principle of "comprehensive and easy to realize through multiple technical means". The scope of task selection includes: comprehensive experiments, university students' innovation programs, "Challenge Cup" programs, and successful cases in pioneering scientific tasks, from which the innovative parts can be selected to avoid excessive difficulties.

(b) Project importing

One student is assigned with one task, they are encouraged to choose and fulfill the tasks independently, required to clearly understand the contents and targets of the tasks, introduce their own tasks and analyze the problems publicly in class, so as to arouse their curiosity, guide them to think actively and figure out the possible innovation points. Through the data collection, sorting and analysis, students will learn to think critically and independently, their innovative thinking will be enhanced, and they will be able to give primary project designs through the sorting and systematization of tasks.

(c) Project implementation

Students can communicate with others on their primary project designs by groups, give their suggestions, sort out and analyze the new ideas in group discussion, in this process students' innovative thinking will be enhanced. Moreover, the virtual simulation technology can be applied to demonstrate the project feasibility and present a rational experiment task design, all problems and difficulties emerging in the task implementation will help strengthen students' wills, cultivate their innovation awareness and enthusiasm.

(d) Project completion

Students' works should be tested and the final reports are needed for the completion of projects, and the work examination focuses on innovation and novelty, and takes functions as the secondary examination standard. Students are instructed to further analyze their innovations during the task in the report and put forward the future direction of innovation, so that they will learn to think about, analyze, solve and conclude the problems. The final works should be compared with the project designs and analyzed, the final reports should specify the innovation points, problems and to-be-modified parts, which will further enhance students' innovative thinking and abilities.

4. IMPLEMENTATION EFFECTS

Through the implementation of experiment projects, it was found that students learned to think actively, had the courage to attempt in face of difficulties, and their innovative thinking was fully trained, and innovation abilities greatly improved. After three years of efforts, the new experiment teaching model helped us to obtain various new ideas and works, from which outstanding works were selected to participate in many scientific innovation contests and make remarkable achievements, including the First Price in the Sixth National Collegiate Optoelectronic Design Contest, the Second Price in the Fifteenth "Challenge Cup" National Collegiate Extracurricular Academic Competition, the Second Price in the Third National Youth AI Innovation and Venture Convention, the Top-grade Award in the Fourteenth "Challenge Cup" Collegiate Extracurricular Academic Technological Contest of Guangdong Province.

CONCLUSION

To cultivate students' innovation awareness, the optoelectronic circuit experiment course based on independence and comprehensiveness breaks through the conventional model of traditional experiment lessons dominated by textbooks, teaching aids and teachers, by applying "five changes and three integrations". Students are able to fully play their subjective initiative, choose the experiment tasks independently within the given scope and difficulty of profession, design and make their own projects with practical functions. Through the reform attempts in the experiment teaching of optoelectronic information science and engineering students of three different grades, the results showed that students' innovation abilities were highly promoted, and outstanding teaching efficiency was achieved.

Teachers through the new experiment course better recognized the significance of innovation training in college education, applied more pertinent teaching means to guide students to think actively, point out and solve problems, enhance their innovative thinking. In the new experiment teaching, students recognized that the innovation requires active thinking to figure out problems, and all details must be well prepared for the project design, moreover, they must have the courage to face the obstacles and difficulties, and to make new attempts. In future, we will keep trying to improve the teaching model and system of the experiment course, so as to further enhance students' innovation awareness and abilities, and train more high-quality talents with innovative thinking.

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