

A whole-process progressive training mode to foster optoelectronic students' innovative practical ability

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ABSTRACT

This article analyzes the features of fostering optoelectronic students' innovative practical ability based on the knowledge structure of optoelectronic disciplines, which not only reveals the common law of cultivating students' innovative practical ability, but also considers the characteristics of the major: (1) The basic theory is difficult, and the close combination of science and technology is obvious; (2) With the integration of optics, mechanics, electronics and computer, the system technology is comprehensive; (3) It has both leading-edge theory and practical applications, so the benefit of cultivating optoelectronic students is high; (4) The equipment is precise and the practice is costly. Considering the concept and structural characteristics of innovative and practical ability, and adhering to the idea of running practice through the whole process, we put forward the construction of three-dimensional innovation and practice platform which consists of "Synthetically Teaching Laboratory + Innovation Practice Base + Scientific Research Laboratory + Major Practice Base + Joint Teaching and Training Base", and meanwhile build a whole-process progressive training mode to foster optoelectronic students' innovative practical ability, following the process of "basic experimental skills training - professional experimental skills training - system design - innovative practice - scientific research project training - expanded training - graduation project": (1) To create an in-class practical ability cultivation environment that has distinctive characteristics of the major, with the teaching laboratory as the basic platform; (2) To create an extra-curricular innovation practice activities cultivation environment that is closely linked to the practical application, with the innovation practice base as a platform for improvement; (3) To create an innovation practice training cultivation environment that leads the development of cutting-edge, with the scientific research laboratory as a platform to explore; (4) To create an out-campus expanded training environment of optoelectronic major practice and optoelectronic system teaching and training, with the major practice base as an expansion of the platform; (5) To break students' "pre-job training barriers" between school and work, with graduation design as the comprehensive training and testing link.

Key words: Experimental teaching; undergraduate students; innovative practical ability; training process; integrated design

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1. INTRODUCTION

Practical ability is the subject’s capability to consciously explore and transform the object on purpose [1-3]. Innovation is the ability to carry out creative activities, which is based on knowledge and skills, and it is also a comprehensive ability corresponding to the pilot, overall and universality of innovative spirit [3,5-7]. Practical ability and innovative ability are closely related. And it is generally believed that practical ability plays a basic and supporting role [3,8]: practice is an important prerequisite of forming and developing innovative capacity, and is the important carrier and key link for cultivation and development of innovative capacity as well [9-11]. Besides innovative ability also promotes and leads the development of practical ability.

Further analysis of the characteristics and connotation structure of practical ability is conducive to forming and developing into a systematic, diversified and multi-level innovation and practice training process [4]: (1) practical ability has characteristics of both practice and capacity, including practicality, dynamic generality, stability, acquisition, specificity, individuality and explicitness; (2) considering from the horizontal structure, practical ability can be divided into hands-on ability, daily life practical ability, professional activities, practical ability and interpersonal skills; (3) while from the vertical structure, the structure of practical ability includes basic practical ability, comprehensive practical ability and innovative practical ability of three levels. As shown in Figure 1 (the direction of the arrow in the figure shows the impact that teaching and scientific research activities on the practical ability cultivation) [9, 10].

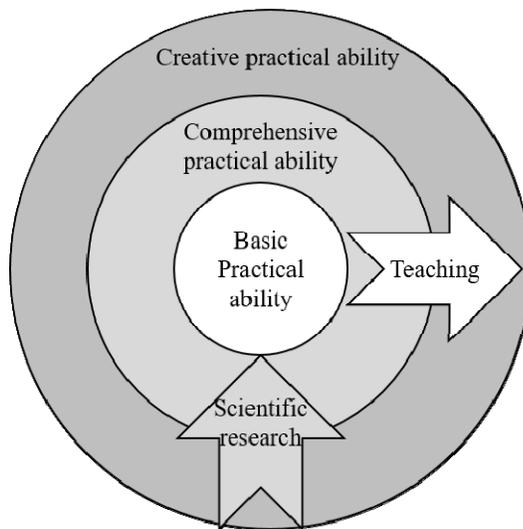


Figure 1. The vertical structure of practical ability.

Based on the characteristics of optoelectronic major we consider the concept and structural characteristics of innovative and practical ability, and adheres to the idea of running practice through the whole process. And then we have systematic investigation on the whole process of fostering optoelectronic students’ innovative practical ability to optimize it. Finally we put forward whole-process progressive training mode to foster optoelectronic students’ innovative practical ability.

2. KNOWLEDGE STRUCTURE OF OPTOELECTRONIC DISCIPLINES AND THE FEATURES OF FOSTERING STUDENTS' INNOVATIVE PRACTICAL ABILITY

2.1 Typical structure and discipline knowledge features of optoelectronic systems

The typical structure of an optoelectronic system can be summarized as four parts: optoelectronics, information, feedback control and precision mechanicals (as shown in Figure 2). The optoelectronic part mainly involves light sources, optical transmission, photodetection and some other professional core knowledge. The information part mainly deals with the knowledge content of electronic circuits and computer signal processing and control. The trunk discipline related to the feedback control part is control science and engineering, of which the connotation can be integrated into the information part. And the trunk discipline involved in precision machinery part is mechanical engineering. Therefore, from the perspective of optoelectronic systems, optoelectronics is a typical interdisciplinary subject, with optical engineering as a backbone, and with physics, electronic science and technology, computer science and technology, communication engineering, control science and engineering, mechanical engineering and some other disciplines as a support. Besides it crosses math, material science and engineering, electrical engineering, software engineering and some other disciplines.

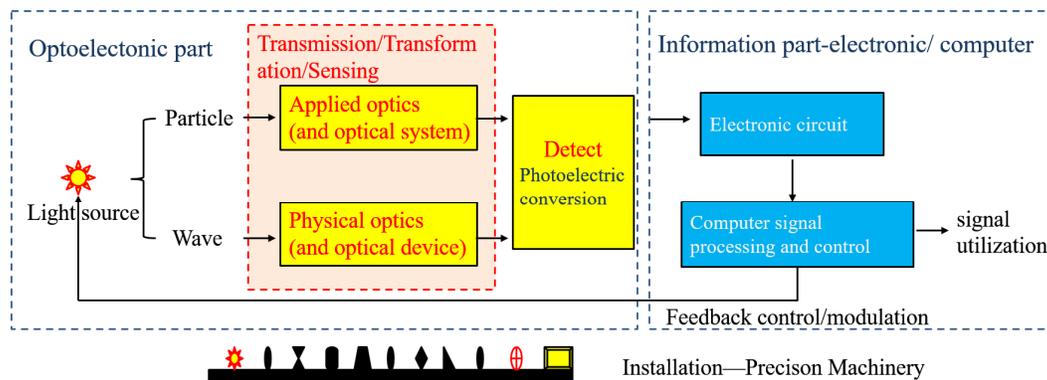


Figure 2. Typical optoelectronic system and the related knowledge structure.

The discipline of optoelectronics has the characteristics of interdisciplinary and integration. As a result, in training process of fostering optoelectronic students, it is necessary to highlight the characteristics of optoelectronics, but also to stress systematic knowledge. Without prominent properties of optoelectronics, graduates with miscellaneous knowledge of photoelectric, electronic circuits, computers and some other aspects may have no vantage of major. On the other hand, students without systematic knowledge may be able to develop a specific optoelectronic element but cannot build an optoelectronic system with certain functionalities. As a result, their job adaptability will be poor.

2.2 The features of fostering optoelectronic students' innovative practical ability

According to the typical structure of an optoelectronic system and the knowledge characteristics of the discipline, the features of fostering optoelectronic students' innovative practical ability has the common law of cultivating students' innovative practical ability as well as the characteristics of the major: (1) The basic theory is difficult, and the close combination of science and technology is obvious; (2) With the integration of optics, mechanics, electronics and computer, the system technology is comprehensive; (3) It has both leading-edge theory and practical applications, so the

benefit of cultivating optoelectronic students is high ; (4) The equipment is precise and the practice is costly.

3. OPTIMIZATION AND PRACTICE OF FOSTERING OPTOELECTRONICS UNDERGRADUATES' INNOVATIVE PRACTICAL ABILITY

Adhering to the idea of conducting practice through the whole process, we construct a three-dimensional innovation and practice platform which consists of “Synthetically Teaching Laboratory + Innovation Practice Base + Scientific Research Laboratory + Major Practice Base + Joint Teaching and Training Base”, and provide a more comprehensive, systematic and normative content process and environment to develop practical ability (as shown in figure 3).

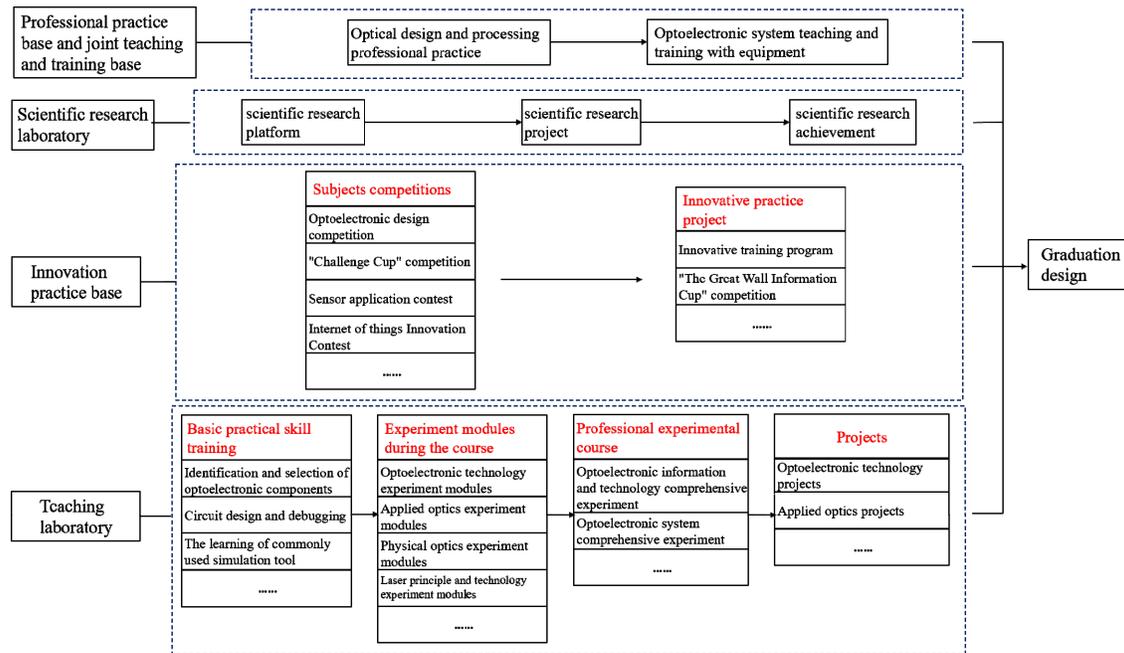


Figure 3. The system of fostering undergraduates' innovative practical ability.

3.1 To create an in-class practical ability cultivation environment that has characteristics of the major, with the teaching laboratory as the basic platform

Relying on the Optoelectronic Engineering teaching laboratory for undergraduate in our college, we set the basic practice skill lectures, experiment modules during the course, professional experimental courses, projects and some other links to foster students' comprehensive practical ability and to help them lay a solid foundation of basic optoelectronic practical skills. Currently, there are 9 categories of 62 experimental modules and projects in total to support the links of professional curriculum experiments, experimental courses, curriculum design, graduation design and some others, of which,

(1) Basic practice skill lectures. Focusing on the short board of traditional optoelectronic experimental teaching, we add basic optoelectronic component identification and selection, optical system assembly and commissioning, circuit design and debugging, commonly used simulation software tools and so on.

(2) Experiment modules during the course. In order to deepen the students' understanding of the theoretical

knowledge learned in class, the corresponding experiment modules are arranged in the core professional courses such as "Physical Optics" and "Applied Optics" and "Optoelectronic Technology". The content is closely connected with the theoretical course and interspersed in the course of theoretical teaching, serving the classroom teaching.

(3) Professional experimental courses. In the professional experimental courses, based on the professional intensions and training requirements, comprehensive and design experiments with both common basis and major characteristics are set up. These experiments can prompt students to develop their own programs, choose experimental equipments, and build experimental system to complete the experimental content.

(4) Projects. At the end of each core professional theory course, students will take advantage of the knowledge learned in this course to complete a small comprehensive project and have an initial experience of scientific research process.

3.2 To create an extra-curricular innovation practice activities cultivation environment that is closely linked to practical applications, with the innovation practice base as a platform for improvement

In order to further improve the students' innovative practical ability and to create a good atmosphere of innovative culture and to guide students jumping from mastering theoretical knowledge to using the knowledge learned to solve real problems, we especially set up a optoelectronic innovation practice base as a bridge for students who cross from the teaching laboratory to Scientific research laboratory. And we build an extracurricular practical ability training system which focusing on co-ordinating the implementation of the scientific and technological innovation and practical activities.

Through the training of various types of extracurricular innovation and practice activities, the students' ability of synthetically using knowledge, practice, social practice, communication, and language expression, and the consciousness of teamwork, innovation and practice have been greatly improved, with fruitful innovation achievements in optoelectronics. For example, the students' work "Intelligent hearing protection system" won the first prize at the International Contest of Applications in Nano-micro Technology. And the work "High speed mobile phone data transmission device based on white light communication" won the first prize of the Tenth International Students iCAN Innovation and Entrepreneurship Competition. It can effectively protect the artillerymen's listening at the conditions of normal communications with talking. And the work "A New Laser Simulation Countermeasure System" In recent years, our undergraduates won first prizes from various domestic and international competitions more than 70 times, and we were awarded for the best organization in the national university students' Opt_Sci_Tech competition for many times.

3.3 To build an innovation and practice environment where forefront leads developments, with the platform of science laboratory

Teaching and research have complementary advantages to cultivate students' ability of innovation and practice, and organically combine the way "overall cultivating" in teaching laboratory and "pointedly improving" in scientific research conditions, to jointly support the cultivation system of students' innovation and practice ability.

(1) Scientific research back-nurture the cultivation of innovation and practice ability. We selected appropriate content to build synthetic experimental projects such as optoelectronic countermeasures and photodetectors, from college's advantage research directions, such as high energy laser, ring laser gyro, fiber optical sensors and photoelectric measurement and control technology. Those projects broaden the horizons of students.

(2) Scientific research platform support to carry out innovation and practice activities. We keep part of high-end

precision instruments and equipments in research laboratories open to students, and support them to compete in various innovation and practice activities such as undergraduates' innovative training and competitions, both of which have improved the levels of cultivating students' practical skills.

Research projects nurture the growth of innovative talents. We consciously cultivate and select outstanding undergraduates to join in scientific research projects and carry out realistic training, so that they can improve themselves and make innovations in practice. We extract graduation design projects from scientific research, thus leading students stepping into academic frontier, cultivating and training innovation and ability with a high starting point. The instructors who cultivate students' innovation quality and guide them to carry out innovation and practice activities are all backbones with rich experience in the area of teaching and researching. They are inexhaustible source who continue giving students cultivation of practice ability.

3.4 To create an out-campus expanded training environment of optoelectronic major practice and optoelectronic system teaching and training, with the major practice base as an expansion of the platform

(1) Professional internship. Our college and the company Xiang Ji Hai Dun have jointly built an "optical engineering" professional practice base, to carry out the production and quality control practice of optical fiber industrial products. Next, our college will build optical fabrication professional practice base, which is partly relied on processing conditions of ring laser gyro of the company Hunan Gaodi, and partly relied on the company "Hunan South China Optoelectronic Technology Co. Ltd". This practice base can help students to strengthen probation and practice ability of optical cold fabrication, coating and assembly technology, to learn modern engineering development, production processes and quality control, and to deepen the engineering practice training for students major in optics.

(2) Teaching and training with optoelectronic system equipments. Through this way, students can recognize, use and understand the equipments to strengthen their ability of analyzing, designing and assembling the optoelectronic system equipments. The methods above also enlighten students to think, to put forward the possible scheme of improving equipment and bring it into practice. After these trainings, students will have more self-confidence in profession and ability for future jobs.

The teaching and training with optoelectronic system equipments carry out inside and outside the campus. Inside the campus, we select 2 or 3 typical optoelectronic system equipments to strongly support the teaching experiment. By dissecting these equipments we can deeply cultivate students' ability to apply, disassemble, maintain and research the optoelectronic system. Outside the campus, with the help of other units, we integrated a large number of dominant resources of optoelectronic systems to build the joint teaching and training base. Every year we send students to the base to visit and learn the optoelectronic system, through which they can comprehend a variety of optoelectronic equipments by analogy.

3.5 To break up the "pre-job training barriers" for students between studying and working, by the synthetic training and testing of graduation design.

Nowadays research-oriented teaching in colleges and universities are not booming and effective. In this case, graduation design is necessary to urge undergraduates to independently apply various disciplines knowledge to solve actual problems. Graduation design further cultivate undergraduates' innovation consciousness and develop their practical ability. As graduation design focuses on exercising and cultivating students, the process of graduation design generally is more important than the results.

Serving for graduation design, we focus on constructing a graduation design platform for optoelectronic countermeasure, highlighting 5 key elements-"joint, system, countermeasures, team and tactics". We make use of optoelectronic equipment and simulation models to carry out team-based and adversarial optoelectronic graduation design and strengthen their understanding and applications of technology and tactics, so as to break up the "pre-job training barriers" for students between studying and working.

3.6 The whole-process progressive model to cultivate students' innovation and practice ability.

According to the theory that teaching and research should be integrated, we construct the whole-process progressive model of cultivating students' innovation and practice ability in sequence-basic practice ability, synthetic practice ability and creative practice ability (as shown in figure 4). In this cultivation model, students' understanding, mastery and application of theoretical knowledge are gradually strengthened, meanwhile the ability of innovation and practice is gradually improved, providing a more comprehensive, systematic and normative content, process and environment to develop practice ability.

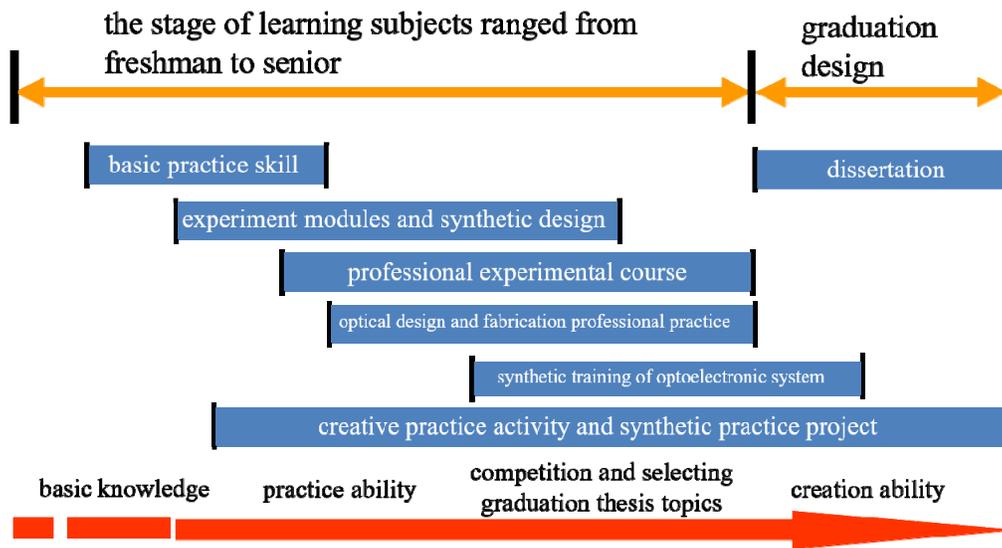


Figure 4. The whole-process progressive cultivating model of innovation and practice ability.

We construct a two-dimension table including experimental levels and categories, and optimally design the ratio of experiments of different levels and categories (shown in table 1). The levels of the experiment can be divided into basic (focus on verifying type), synthesis (focus on designing type), independent innovation (focus on systematic type), extension (such as professional practice, teaching and training with equipments) and so on. The experiment categories include experiment modules during the course, professional experimental courses, projects, professional practice, teaching with equipments, graduation design, innovation competition and so on. The experimental levels and categories constitute a two-dimension table, and calculate the ratio of experiments of every level and type according to the two-dimension table, coming to being the qualitative conclusion based on quantitative analysis. Correspondingly, we reduce the verification experiments further and increase the synthetic designing experiments.

Table 1. Two-dimensional table of experimental level and experimental type.

Level \ Category	experiment modules during the course	professional experimental course	projects	professional practice	teaching with equipments	graduation design	innovation competition
basic	★	★					
comprehensiveness		★	★	★	★	★	★
independent innovation			★	★	★	★	★
extension				★	★	★	★

Next, we will strengthen the requirements of cultivating students' innovative practice ability, clarify the credit requirements of practice part, and present definite credit requirements of students to participate in multiple subjects' training of practice ability and synthetic practice projects. We will implement the credit reward system for students' innovation and practice activities and put up more requirements on the recommended exemption graduates.

4. FURTHER DISCUSSIONS

4.1 Integrally optimize the experimental teaching contents

Integrally design the cultivation methods of undergraduates, postgraduates, and continuing education students' innovation and practice ability, based on the network map of knowledge structure. Based on the network map of knowledge structure, the knowledge system of the undergraduates, postgraduates, and continuing education students is optimized. The mapping relations, supporting relations, prerequisite relations and follow-up relations between practice teaching and theoretical teaching content are systematically summarized. The experimental teaching and classroom education should be tightly combined. We should appropriately reduce teaching time of theory and increase that of experiment (practice), to enhance students' awareness of independent study and develop their ability of solving realistic problems by applying many subjects' knowledge.

Excellent senior undergraduates can take experiment modules for postgraduates as elective courses, while the postgraduates who come from other colleges and majors can also repeat undergraduates' experiment modules of our major. The systematic and synthetic experiments for continuing education students can be exhibited for junior undergraduates, as introductory lessons of optoelectronic technology and application for undergraduates, which will help undergraduates to catch both the key points and the full view of this subject. A part of undergraduates' optoelectronic countermeasures platforms and their graduation designs, and the research achievements of application-oriented postgraduates' dissertations also can be teaching cases or experimental exhibition modules for continuing education students.

4.2 Build a supporting system in which the advantages of teaching and research are complementary to cultivate students' innovation and practice ability

In general, teaching laboratories such as the disciplinary synthetic experimental centers of subjects, innovation centers

(bases, platforms) and so on focus on teaching experiments and engineering practice training in course-teaching stage, which can provide multiple sets of mid-range equipments and experiment sites to satisfy massive students' experimental teaching requirements.

Scientific laboratories mainly serve the needs of research issues. The experimental equipments are advanced, and in small number. It should be said that high-level scientific research conditions are necessary to cultivate students' innovation and practice ability, and we can provide large-scale advanced equipments and the research environment for a portion of students who participate in high-level research projects and scientific experiments on equipments, particularly for postgraduates. However, it becomes more and more difficult to meet the massive students' needs of cultivating practice ability systematically and normally with only the support of research experiment conditions.

Therefore, teaching and research have the complementary advantages to cultivate postgraduates' practice ability. Following that, we can tightly combine the "basic training" of teaching conditions and the "professional elevating" of research conditions. According to the idea of "based on but transcend the subjects", we cultivate the students' ability that using knowledge of multiple subjects to solve synthetic application problems, and create a multi-disciplinary environment and academic exchange atmosphere. Exploring the open and shared operation and management mechanism of laboratory in practice (such as the sharing service platform of equipment and information), we strive to achieve good construction benefits and jointly support the cultivation system of students' innovation and practice ability.

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