Research on the Construction of College Engineering Practice Courses Under the Background of New Engineering

Hongxia Wang[1], Zhipeng Wang[2(✉)], Kun Fang[2], and Ye Li[1]

[1] Beihang School, Beihang University, Beijing, China
{whx2018,liye}@buaa.edu.cn
[2] Electronic Information Engineering, Beihang University, Beijing, China
{wangzhipeng,fangkun}@buaa.edu.cn

Abstract. Engineering training is an important part of engineering education in colleges and universities. Applying theory to practice is not only the significance of practical courses, but also the source of students' learning motivation. All practical teaching ideas and methods need to be carried out around the application. The "electronic engineering technology training" course takes diversified practical electronic products as the carrier and adopts the "2 + X" training mode. Many practical teaching contents such as welding, assembly, debugging and innovative design have been carried out, and interdisciplinary knowledge such as electronic technology, sensor technology, instrument measurement and unmanned aerial vehicle (UAV) has been integrated. Through the combination of principle teaching, practical operation debugging and innovative design experience, the course fully stimulates the interest of junior undergraduates in electronic information engineering, UAV and other related fields, enhances their cognition of multidisciplinary fields, and cultivates their ability to analyze and solve engineering problems as well as comprehensive practice.

Keywords: Engineering training · Hierarchical training model · Electronic engineering technology · Practical teaching

1 Introduction

In order to actively respond to the new round of scientific and technological revolution and industrial transformation, China has put forward the new engineering talent training, focusing on the training of interdisciplinary, comprehensive quality and composite ability, and practical teaching is an effective way to implement and test talent training [1, 2]. The engineering training center of Beihang University (hereinafter referred to as "the center") plays an important role in the engineering education as a base for engineering practice and innovation of the University [3]. Therefore, the engineering training center takes diversified practical electronic engineering products as the carrier, adopts the "2 + X" training mode [4], carefully designs the "electronic engineering technology training" course, guides students to apply theory to practice, and cultivates students' awareness of big engineering concept and practical innovation.

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2 Course Character and Teaching Objectives

The course "electronic engineering technology training" is a public practice course offered by the industrial training center for junior undergraduates of non electrical engineering majors in the University. Through welding exercises, component assembly and identification, circuit schematic diagram analysis, circuit design, circuit debugging, principle and use of basic electronic measuring instruments, standardized completion of technical reports and other links, teachers give lectures and guidance, and students operate alternately enabling students to master electronic technology and operation skills. The 64 class hours of the course plan are arranged in the laboratory. The design, scheme demonstration, review and modification of the improvement training program are coordinated and organized flexibly by the teacher team through online or offline [5] discussions and defense meetings. The specific teaching objectives can be divided into the following three points.

(1) Let students master manual welding technology; Master the basic characteristics, identification and detection methods of electronic components; Master cutting-edge key technologies such as electronic measurement, circuit debugging and data analysis, emphasize both the depth and the breadth of knowledge;
(2) Let students master the application technologies such as electronic circuit schematic identification and design, FM radio, UAV production, and pay attention to the combination of theory and practice; Let students master the standardized writing method of engineering technical reports; Cultivate students' consciousness of abiding by safety technical rules and improve students' overall comprehensive quality.
(3) Let students complete the closed-loop practical teaching of "theoretical learning - basic training (required + optional, DIP + SMT) - debugging analysis - report summary - improving training (comprehensive innovative design experience, optional, group cooperation)" with the hierarchical training mode of "foundation - integration - expansion - innovation".

3 Development and Design of Practical Teaching

The materials used in the course mainly include welding tools (electric soldering iron, file, side cutters, etc.), measuring instruments (power supply, multimeter, oscilloscope, etc.), welding exercise board (hole board), supporting components (chips, resistors, capacitors, etc.), circuit board (pulse width modulation DC regulated power supply and FM radio), sensor box and UAV KIT Parts (rack, F4 flight control, motor, electronic governor, switchboard, etc.). The framework of the course structure is shown in Fig. 1.

All the tools, instruments and hardware accessories used in the course are provided by the laboratory. Besides, one electronic engineering technology training guide and one instrument and laboratory operation manual are provided. In addition, since the spring semester of 2020, circuit design and simulation testing have been added: Altium designer software is used to draw circuit schematic diagrams and PCB layout, master the drawing method of schematic diagrams, and deepen the understanding of product circuit principles and PCB manufacturing rules; Through the virtual instruments (virtual ammeter, oscilloscope, etc.) in Proteus Software, the simulation test of circuit diagram

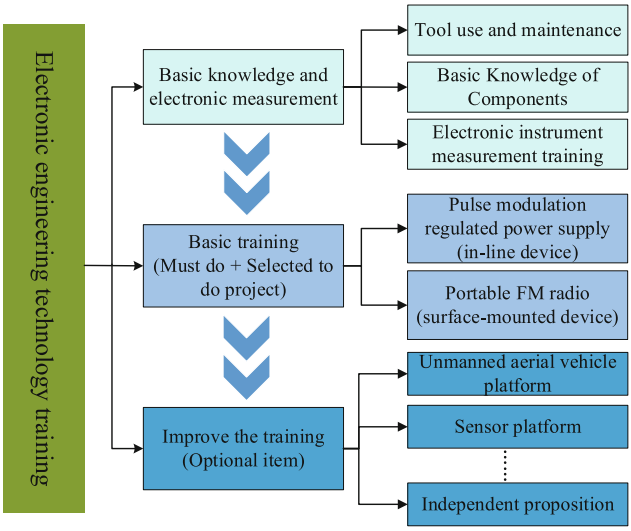


Fig. 1. Curriculum structure framework

can be compared with the actual measurement results to help students better understand the test data and waveform. The course content is set in a menu, which is divided into two categories: basic training items and expansion and innovation items. The teaching system is shown in Fig. 2. The basic training items are divided into required and optional ones, and the teaching is classified according to the majors of students; The expansion and innovation project adopts the system of "Student Voluntary application + teacher screening", and establishes a curriculum teaching system through the four levels of "foundation - integration - expansion - innovation" to achieve diversified talent training.

A large number of survey data accumulated through 18 rounds of teaching in three semesters show that more than 98% of students are very interested in the practical course of combining skill training with hands-on practice, think it is practical, and think that the teaching method of learning by doing is more efficient. At the same time, they show strong desire for product diversity and innovation. Therefore, this course adopts the teaching mode of combining teaching with practice, teaching in layers, practicing while teaching, and teaching in modules. The teaching, training and assessment of each module are completed in the module. Each teaching module is relatively independent and interrelated. The arrangement of teaching modules is based on the principle of going from shallow to deep, and each module is the basis of subsequent modules, which is carried out in sequence. During the practice, teachers teach basic knowledge, and students actually complete the training content independently. When students encounter problems, teachers guide students to find solutions one-on-one, and check the implementation effect [6], so as to train students' ability to find, analyze and solve problems.

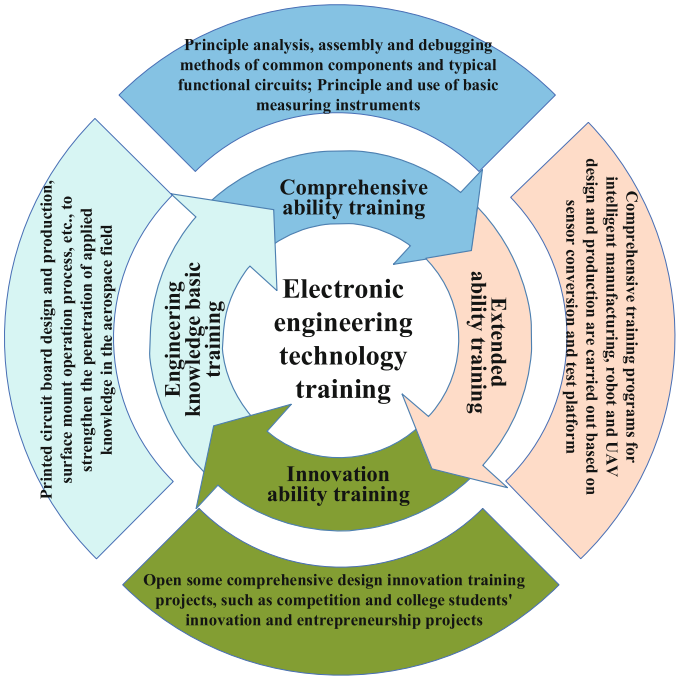


Fig. 2. Hierarchical teaching system of "foundation-integration-expansion-innovation"

3.1 Fundamentals of Welding Technology and Component Identification

The audience of the course determines the introduction method, content arrangement and implementation design of the course. This course is mainly aimed at junior undergraduates of non electrical majors, who are still in the preliminary stage of general education. How to cut into the theoretical teaching link from point to face, let students feel the cutting-edge and practicality of knowledge and technology, and then promote their interest in learning is the focus of this course. First of all, in combination with the current situation and the course content, guided by the craftsman spirit, spaceflight spirit and model worker spirit, students can initially understand the importance of the course, the rigor of engineering and the necessity of working hard. Then the students are led to understand the laboratory, explain the requirements of engineering training operation specifications and safety education. Moreover, manual welding and advanced welding process technology popular in the market are introduced, so as to preliminarily understand and master the use and maintenance methods of our tools and instruments. Finally, the students complete the welding process training independently according to the course requirements.

Component identification involves a lot of subject knowledge and models. Considering the weak basic level of students and the limitation of class hours, it is impossible to cover all components in the course content, and even the types can not be fully covered. Therefore, this part focuses on the identification and marking of resistors, capacitors, inductors and transistors, taking the pulse width modulation stabilized voltage power

supply and radio as the practice carrier of this course. The functions of pulse width modulation chip 3524 and TDA7088T pin are introduced, and the instrument measurement methods and assembly specifications of these components are explained. Let students understand the role of each component in the circuit, master the identification of schematic diagram, the corresponding relationship between schematic symbols and actual components, and the corresponding relationship between schematic diagram and PCB diagram. Through the knowledge points explanation, demonstration, effect evaluation and problem correction of the above two parts, students can master the skills of manual welding, establish basic cognition of tools and instruments, acquire the ability to draw inferences from one instance, and then lay a good foundation for the learning of the later course content and skilled application in life and work in the future.

3.2 Manufacture of Pulse Width Modulation Stabilized Voltage Power Supply

The pulse width modulation regulated power supply has the following characteristics of practical teaching product selection for non electrical majors [7]. This part is the application of welding technology and component identification knowledge and skills. In this part, students should classify all components, and then measure, record and install them orderly according to standard electronic engineering operating rules, so as to develop standardized and efficient engineering habits. Through the observation of actual PCB boards, students can fully understand PCB manufacturing process knowledge such as electrical layer, solder resist layer, silk screen printing and through hole. Through hands-on assembly, students can truly understand the corresponding relationship between physical components and PCB diagrams, the relationship between schematic diagrams and PCB diagrams, pay attention to the distinction of component polarity and the correspondence of pins, pay attention to the differences between GND, power supply and general electrical wiring, and understand the rules and constraints of PCB board wiring more deeply. Figure 3 is a sample physical picture of pulse width modulation regulated power supply made by students of basic training program.

Through this part of training, most students can master basic electronic circuit assembly skills, and a few will have welding problems such as continuous soldering, false soldering, pad falling off, and assembly problems such as reverse polarity of components and misplaced chip pins. This part is a test of welding practice and component knowledge, and is also the basis of chapter 2.2. Therefore, in order to ensure the quality of follow-up teaching and improve the comprehensiveness, fairness and rationality of assessment, the course has designed multiple assessments, focusing on the process and diversity of assessment. The assessment content is comprehensive, covering theoretical knowledge such as welding knowledge, component knowledge, circuit principle of the course carrier used, welding skills, assembly skills, instrument measurement operation skills and circuit analysis and debugging skills, thus avoiding unscientific problems caused by using only one assessment at the end of the term. After the students complete this part of the training, the course will organize product acceptance, and multiple teachers will check, grade (accounting for 20%), correct and guide the students' works in groups at the same time. Through the process of inspection and correction, students have not only consolidated the key points but also deepened their understanding, and mastered

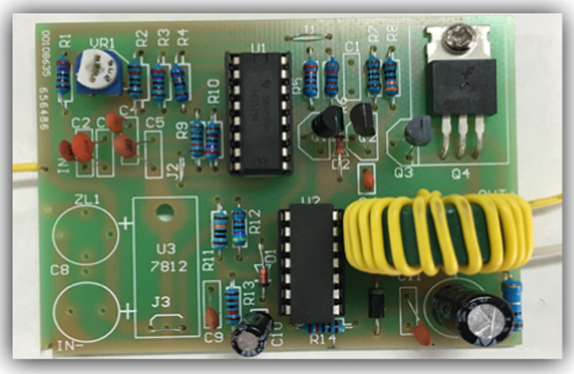


Fig. 3. Sample physical picture of pulse width modulation regulated power supply made by students of basic training program

the repair methods, such as solving the problem of pad falling off through bridging and connecting, and have a deeper understanding of the principle of the electrical layer.

3.3 Principle and Debugging of Pulse Width Modulation Regulated Power Supply

The pulse width modulation regulated power supply used in the course belongs to the switching regulated power supply. The teacher enters the new course content by asking questions and combine the feedback to give the important components of the regulated power supply, and make a simple analysis. Then, the implementation of each module is analyzed in modules, including rectification, filtering and voltage stabilization. On this basis, the principle of the DC regulated power supply realized in this lesson is analyzed as a whole, as well as the debugging and troubleshooting methods of the circuit board. In the process of practice, students' observation, analysis, reasoning and synthesis abilities are cultivated, and good standardized engineering practice habits and thinking patterns are formed. At the same time, it can stimulate students' interest and desire to explore and experience the happiness of success in practical learning. Similarly, this session includes a process assessment, accounting for 50%. The form includes oral examination, practical demonstration and report, which mainly evaluates students' instrument operation skills and ability to record experimental reports in a standardized manner.

3.4 Surface Mount Technology and FM Radio

FM radio is very close to life and contains another electronic process technology: surface mount technology. It is a very suitable practice carrier. An example of the work completed by students is shown in Fig. 4, in which (a) is the component surface and (b) is the welding surface. By leading students to observe and compare pulse width modulation regulated power supply, radio components and PCB boards, they can better summarize the characteristics of patch components, explore and infer their applicable

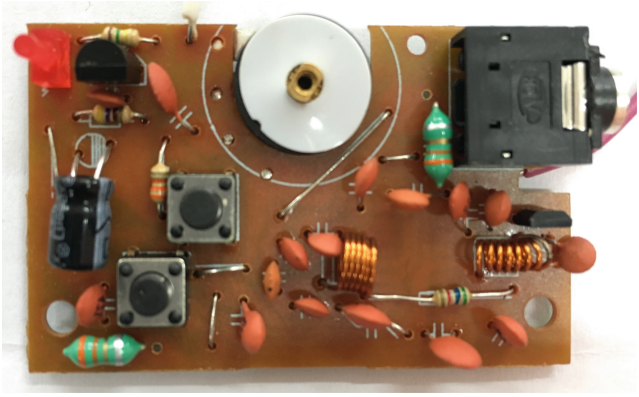
welding technologies, and analyze their principles. Teachers give guidance through principle analysis and practical demonstration, and combine teaching with practice, so as to highlight the key points and break through the difficulties. With the help of multimedia operation video demonstration, students can understand key operation technologies, combine with the teacher's summary of precautions in streaming soldering operation, and then comprehend and master streaming soldering skills and repair methods of wrong solder joints through hands-on practice.

Students have a weak foundation in the principles, so we should pay attention to increasing interest and interactivity in its explanation. Radio principles are part of communication. We can introduce some related magical phenomena in nature, including the super perception of animals to earthquakes, to guide students to explore their scientific explanation. By listening to audio at different frequencies, students can understand the frequency range of signals and the concept of broadcast signal transmission, which can stimulate students to think and summarize problems, and find ways to solve the problem of how to make signal transmission farther and more effective. Combined with the teacher's explanation, they can better understand the broadcast signal transmission process and modulation mode. Finally, through the analysis of the principles of FM radio used in this course, they can understand the concepts of heterodyne and intermediate frequency, and complete the debugging practice of channel selection and frequency coverage. The process assessment of this link accounts for 10%, mainly assessing whether the products completed by students are standard and beautiful, as well as the reliability and frequency coverage performance of products. This set of teaching and learning methods can help students learn to observe and analyze problems, explore and solve problems, enable students to understand and master a set of methods that can draw inferences from one instance to solve engineering application problems, and embody a teaching method of "giving them fish, and teaching them to fish".

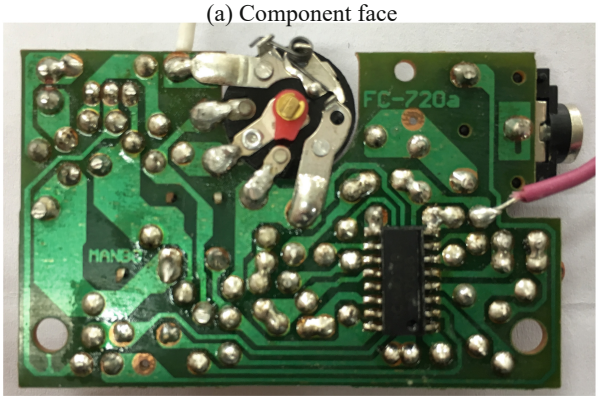
3.5 UAV and Sensor Platform

UAV and sensor platform are the training content of course improvement, which belong to comprehensive innovation experience projects [8]. They are an effective way for students to apply what they have learned and test their engineering practice skills. This module is optional, and the project topics are flexible. There are mainly curriculum specified projects, such as UAV, and independent propositions. The main purpose is to further improve students' engineering skills and cultivate students' ability to innovate and cooperate. It can well stimulate students' desire for exploration and enthusiasm for learning.

In order to ensure the value and operability of the exploration experiment, teachers need to focus on the feasibility and difficulty of the project for independent proposition projects. Experiments can only be carried out if the proposition is verified and approved. The exploratory comprehensive improvement training is conducted in groups of three to five people. In addition to the above assembly tools and debugging instruments, each group is allocated a set of UAV kits or a sensor kit box (42 sensors and a raspberry pie) and several breadboards and DuPont lines according to the selected topic. The UAV assembly and commissioning instruction manual or sensor instruction manual will be issued in a supporting manner, and important knowledge points will be demonstrated



(a) Component face



(b) Welding surface

Fig. 4. An example of student works of comprehensive training program

and explained through teachers. It will be completed by the student group through division of labor and cooperation, depending on the project, which may include mechanical structure assembly, circuit welding and testing, assembly and general adjustment, etc. The principle of student-oriented will be followed in the whole process, and teachers will provide personalized guidance according to the needs of students. The assessment at this stage accounts for 20%, including 5% of the rationality of the scheme, 8% of the innovation, 5% of the product completion, and 2% of the collaboration and communication ability (teacher evaluation and intra group mutual evaluation). Those who are evaluated as excellent in the project can be given additional points and excellent works exhibition as appropriate. Projects with good results after multiple rounds of experiments can also be included in the curriculum carrier material library, so as to establish a rich and sustainable curriculum carrier library, forming a good cycle to promote the development of the curriculum. An example of the work completed by students of the expansion and innovation project is shown in Fig. 5.

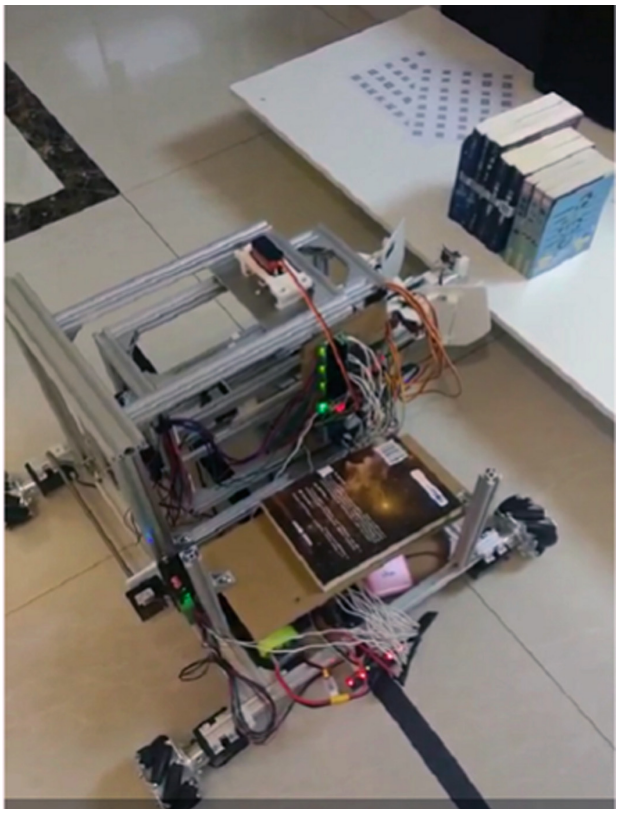


Fig. 5. An example of works completed by students of expansion and innovation projects

4 Effect Analysis of the Practical Teaching of the Hierarchical Training Mode of "Foundation-Integration-Expansion-Innovation"

4.1 The Teaching Carrier is Hierarchical and Sustainable

Pulse width modulation regulated power supply and radio are practical carriers of electronic engineering technology that are closer to life. Driven by the production of practical products, students can deeply participate in the whole teaching process by combining self-study and mutual learning, discussion and verification. In addition, improving the training links gives students enough space to explore and innovate, and improves the level and diversity of teaching. In addition to the current learning of welding and assembly technology, students are allowed to participate in the design of product systems, including performance analysis, circuit system building, debugging, simulation and physical testing, as well as data recording and processing analysis, so that the process of electronic engineering technology training is more complete, diverse and comprehensive. In addition, through more cutting-edge ideas and continuous innovation experiments, the

curriculum carrier library has become more and more rich and innovative, maintaining the cutting-edge and sustainable development of the carrier.

4.2 Comprehensive and Process Assessment is Scientific

This course has designed many process-based comprehensive assessments. Each assessment is not only a demonstration of results, but also a test of skills, and also an opportunity for correction and progress. The process stage assessment is more conducive to stimulating students' learning enthusiasm, and targeted and timely error correction is more convenient for accurate mastery of skills training. In addition, each assessment is comprehensive. The assessment subjects include teachers and students. The assessment contents include oral examination, practical operation, report, etc. The assessment is comprehensive and multi angle, making it more comprehensive and scientific. Since the beginning of the course, the course has been highly praised by students. The survey data of more than ten rounds of students in the past three years show that more than 96% of students are satisfied with the learning effect of the course. The excellent works of the students after innovation training have won the first prize of the school level "Fengru Cup" innovation production, the national invention patent authorization, and published papers. The teaching effect is remarkable.

5 Conclusions

Taking the course of "electronic engineering technology training" as an example, this paper proposes a teaching practice plan of "foundation-integration-expansion- innovation" hierarchical training mode with diversified actual electronic products as the carrier, which integrates many interdisciplinary knowledge such as electronic technology, sensor technology, instrument measurement and unmanned mechanism. Through the combination of virtual simulation and physical practice, students can better understand the working principle of circuits, add comprehensive innovation experience projects as upgrading training, and establish multi-level teaching gradients to meet the needs of students with different knowledge levels. In addition, the multi-level practice and process assessment of the course not only greatly improve students' autonomy in learning, but also cultivate students' ability to analyze and solve engineering problems and comprehensive practice. Moreover, it further maintains the continuous updating of the curriculum carrier library, forming a good cycle to promote the development of the curriculum.

References

1. Xie Huiming, Yang Duan, Qin Yang. Exploration on practical teaching of electronic engineering training in colleges with aerospace characteristics [J]. Western China quality education, 2019, 5(11):182–183.
2. Hua Fan, Huajiang Xie, Sujie Li, Xinni Wang, Xingning Ye, Weijian Chen. Reform in Innovation Training Program of Electronic Engineering: Integrating Theory into Practice [J]. Research and exploration in laboratory, 2021, 40(03):153–159.

3. Wang Bo, Wang Meiling, Liu Wei, Jin Ying, Xiao Xuan. Teaching Reform in the Electronic Technology Curriculum Design Based on Outcome-based Education Concept [J]. Research and exploration in laboratory, 2019, 38(09):224–227.
4. Luo Wei, Shao Xia. Design and Practice of Project Teaching in "2+X" Engineering Training Mode [J]. Research and exploration in laboratory, 2018, 37(02):235–238.
5. Liao Qiuli, Bai Yanli, Wu Shuqin, Fan Yong. Practice of Teaching Electronic Engineering Training with Online and Offline [J]. Electronic technology, 2020, 49(04):136–137.
6. Yan Yong, Liu Xuejun, Kang Yong, LAN Bo, Zhou Yiming. Establishment and Implementation of Practical Teaching Evaluation System for Electronic Engineering Design [J]. Experimental technology & management, 2018, 35(10):166–169+180.
7. Yang Kai, Luo Xiaoshan, Zhang Wuqian, Zhu Jiwu, Yu Li. Organization management of electronic practice in engineering specialty [J]. Experimental technology and management, 1997, 14 (1): 52-54.
8. Peng Lijun, Han Hang. Reformation for Comprehensive Experiment of Electrical and Electronic Technology Based on International Engineering Education Accreditation [J]. Research and exploration in Laboratory, 2018, 37(07):178–181+290.