Reform of Experimental Teaching based on Quality Cultivation

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ABSTRACT

Experimental teaching plays an import part in quality education which devotes to cultivating students with innovative spirit, strong technological talents and practical ability. However, in the traditional experimental teaching mode, the experiments are treated as a vassal or supplementary mean of theoretical teaching, and students prefer focus on theory to practice. Therefore, the traditional experimental teaching mode is difficult to meet the requirements of quality education. To address this issue, the reform of experimental teaching is introduced in this paper taking the photoelectric detector experiment as the example. The new experimental teaching mode is designed from such aspects as experimental content, teaching method and experimental evaluation. With the purpose of cultivating students' practical ability, two different-level experimental content is designed. Not only the basic experiments used to verify the theory are set to consolidate the students' learned theoretical knowledge, but also comprehensive experiments are designed to encourage the students to apply their learned knowledge to solve practical problems. In the teaching process, heuristic teaching thought is adopt and the traditional 'teacher-centered' teaching form is replaced by 'student-centered' form, which aims to encourage students to design the experimental systems by their own with the teacher's guidance. In addition to depending on stimulating the students' interest of science research, experimental evaluation is necessary to urge students to complete the experiments efficiently. Multifaceted evaluation method is proposed to test the students' mastery of theoretical knowledge, practice ability, troubleshooting and problem solving skills, and innovation capability comprehensively. Practices demonstrated the satisfying effect of our experimental teaching mode.

Keywords: experimental teaching, quality education, innovation ability

1. INTRODUCTION

The development of information technology proposes higher and higher demands to higher education system, which aims to cultivate students with basic high quality, comprehensive ability, and creative capability. Experimental teaching plays an extremely important part in the Higher Education[1]. However, many universities are still using the traditional experimental teaching mode, which can't train the students with practice ability very well and is also not beneficial for innovative awareness and creative ability cultivation on students[2]. In this paper, the photoelectric detector experiment is taken as the example to point out the main problems in traditional experimental teaching mode, and then the reform of experimental teaching is proposed.

2. THE PROBLEMS IN TRADITIONAL EXPERIMENTAL TEACHING

The "Photoelectric Technology" is a required course for students in optical engineering and its purpose is to cultivate students to solve engineering problem with the knowledge of optical technology, microelectronics technology, precision machining technology and computer technology comprehensively. As one of serious parts, the principle and property of photoelectric detectors are required. The detectors have several important characteristics such as photoelectric characteristic, spectral sensitivity, spectral characteristic, current-voltage characteristic, temperature characteristic, frequency characteristic and so on. Though a wide variety of characteristics should be considered to choose a right detector, spectral characteristic and response time are the most important of all. A detector will have different photoelectric conversion performance while the wavelength of the incoming light changes. So the spectral characteristic

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is defined to describe the photoelectric conversion performance of photoelectric detectors with respect to the wavelength of the incoming light. It reflects the wavelength range of light that the photoelectric detector can detect. In practice, in order to detector the incoming light effectively, we would better choose the detector whose spectral matches the spectral of the light. In addition, when a ray of light falls on a photoelectric detector, the electric signal will increase gradually until it reaches the maximum value. Therefore, the response time (including rise time and drop time) is defined to evaluate the speed of the detectors. Obviously, the detectors with long response time are not suitable for the cases which require high speed. We hope the students can master the principle and property of photoelectric detectors, and what's more, the students can solve practical matters using their theoretical knowledge. However, without experiments, the knowledge imparted by the theoretical teaching is only realm of fancy without any foundation and students can't understand the actual value and application background[3]. As far as we know, the spectral characteristic and response time measurement experiment for photoelectric detectors has been set in many universities. However, in some universities, the students' overall quality can't be highly improved as the traditional experimental teaching mode is adopted.

The main problems in the traditional experimental teaching mode are summarized as follows.

Many students attach little importance to experiments, and neglect preview. Generally speaking, some experiments can't be set with the theoretical course at the same time. In some universities, theoretical course are set in one term, and the experiments are set in another term. In this case, students nearly forget the theoretical knowledge related to the experiment. If they don't preview, at the beginning of the class, they may know nothing about the experiments and have no way to start. Then, they need to take much of their experimental time to understand the principle and operating steps of the experiment. Hence, the practical time is compressed. In the limited time, most of students are only able to finish the basic experiment for theoretical verification and have no time for comprehensive experiment to further improve their practical ability.

The experiments depend on theory verification rather than innovative awareness cultivation. The experimental content mainly focuses on the theory validation, and the experiment become a vassal or supplementary mean of theoretical teaching. For example, in the photoelectric detectors' spectral characteristic measurement experiment, if the students are only asked to observe the output of the detectors when the wavelength of the input light changes, they can have more intuitive grasp of the spectral characteristic, but they still don't understand its actual value in practice. Besides, the experiment for theory verification is very hard to stimulate the students' interest as they can predict the results using their theory knowledge. As students don't think the experiment is helpful to their comprehensive quality enhancement, their enthusiasm can't be mobilized.

In the teaching process, teachers always tend to emphasize the experimental operation and neglect the principle and construction of the laboratory apparatus. In the class, the teacher often chiefly introduce the experimental operation in detail, and what the students need to do is just to follow the teacher's conduction step by step. In this way, Students can only conduct experiment passively, lacking of proactive thinking and losing the space for independent thinking. They can finish the experiment even without understanding the principle. In the spectral characteristic measurement experiment, a grating monochromator is adopt to obtain monochromatic lights with different wavelength. The student may use it successfully under the guidance from their teachers, but they can't answer why the grating monochromator is adopted, how it work, and whether there are other methods to obtain monochromatic lights without a grating monochromator. Through the class, they will acquire nothing from the experiment except for some data which can verify the theatrical knowledge. Under this circumstance, the experiment can't help student to enhance their ability of solving practical problems, and we can say that traditional experimental teaching fails to meet the requirements of the quality teaching.

Experimental teaching organization focuses on the uniformity[4]. Students have differences in their foundation, intelligence, acceptance and ability. However, they are always required to conduct same experimental contents. In these circumstances, students with strong ability have less opportunity to carry out more comprehensive researches and their ability is difficult to be further improved.

3. REFORM OF EXPERIMENTAL TEACHING

Confronted with the problems lying in the traditional experimental teaching, it's a social demand of us to design new experimental teaching mode, with the aim of strengthening the knowledgeable practice and skill cultivation. The reform of our new teaching mode can be conducted according to the following aspects:

a) Two different-level experimental contents

According to the difference between students, the contents of the experiment can be divided into basic experiment and comprehensive experiment. The former one is mainly focuses on strengthening the students' perceptual cognition of what they have learned, helping the students to understand the basic theory of the relevant course, and stimulating students' enthusiasm for learning. For the students of higher academic capability, the comprehensive experiment is designed to cultivate the students to analyze and solve practical problems.

In the spectral characteristic measurement experiment, in addition to the basic experiment which only requires students to set up a laboratory system to measure the spectral characteristic of the given detectors, we encourage students to measure the spectrum of an unknown optical filter or some liquid such as oil, water, alcohol and so on. In such experiments, they couldn't get correct result unless the suitable detectors whose spectral characteristic matches the one of the detected objects are chosen. This experiment can help students to understand the importance of the spectral characteristic in the practice.

In the response time measurement experiment, all students need to measure the response time of detectors using the directive method, in which output can be observed through an oscilloscope while the input optical signal is in the form of square wave. In the end, according to the definition of the response time, it can be obtained only just by measuring the rising edge and descending edge. To further cultivate the students to relate theory to practice, students of higher capability are required to do some comprehensive experiments. For example, as the rise time can be calculated indirectly taking advantage of the relationship between the rise time and frequency characteristic or cut-off frequency, the students are expected to obtain the response time when only the sine optical signals are given. In addition, to make the students have a more deep understanding about the connotation of the response time, an experiment to test the speed of a given turntable is designed. As shown in Fig.1, the DC light will be modulated into the sine light while the turntable is turning at a constant speed, and the frequency of the sine light is proportional to the speed of the turntable. It is known that, due to the response time, the amplitude of the electrical signal output by a detector depends on the frequency of the input light. Therefore, the speed of the turntable can be estimated by measuring the output of the detector.

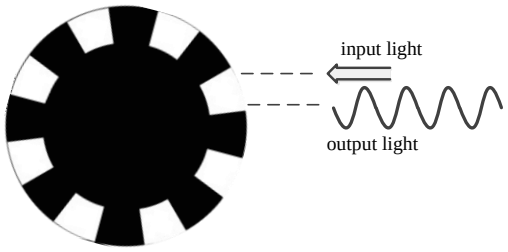

Figure 1. The illustration of the experiment to test the turntable speed by a detector.

b) Student-centered heuristic experimental teaching method

In order to stimulate the students' enthusiasm for experiment and strength their studying initiative, traditional "teacher-centered" experimental teaching mode should be changed into "student-centered" model. During the process of experiment, students have many problems, teachers should know students' confusion promptly and encourage and guide them to seek a method to probe the problems rather than providing the solution method directly. Meanwhile, some communications can be organized to provide students with opportunities to discuss with each other. This can induce students' initiative for study, cultivate students' communication skills and improve their enthusiasm in team work.

At the beginning of the class for spectral characteristic measurement experiment, the teacher should ask some questions such as what is the spectral characteristic of the detector, what is the mean of each point on the spectral characteristic curve, how to measure the ability of a detector to transform the light to electricity, what are the necessary parameter that we should acquire to calculate the spectral sensitivity of a detector, how to acquire, what is the advantage and disadvantage of each method, and so on. Following these questions, students not only understand the principle of the experiment, but also are able to design experimental systems using the provided equipment.

During the experiment, once the equipment are adopt for the experiment, the teacher should ask "why are they adopt, what are their principles and how do they work" to inspire students' exploring inspirit and enhance their engineering experience. If the equipment is packaged, the teacher would better open the housing to help students to understand the principle and construction of the equipment and the real situation of project in operation.

There may be difference between the theory and the result of the experiment. At this moment, the teacher can ask "is the difference caused by wrong operation, the defect of the equipment or some unavoidable reasons such as background

noise, what actions can be taken to decline the error" to make students think and enhance their capability to analyze and solve problems in practice.

c) Multifaceted experimental evaluation

Enthusiasm plays an important role in learning, but evaluation is an effective way to fully inspire the enthusiasm of the students[5]. However, the traditional experimental evaluation which only simply tests the students' mastery of knowledge can't satisfy the requirement. Hence, the experimental evaluation is in sharp need of reform. As the experimental contents include the basic experiment and the comprehensive experiment, multifaceted evaluation method need to be adopt to give evaluation results fairly. The results of evaluation consist of preview, process, report and presentation.

To push the students to preview, the previewing papers are handed to the students at the end of the above class, and then gathered back at the beginning of the class. The preview of the experiment takes up 10%.

The process, including the process of basic experiment (40%) and the process of comprehensive experiment (20%), takes 60% of the final grade. For basic experiment, the evaluation mainly focuses on the attitude of the students, the designed systems, and the experimental results. In the meanwhile, the evaluation of comprehensive experiment pays more attention to the ability to use knowledge to solve problems, innovation and enterprising spirit.

The reports can comprehensively reflect students' initiative and competence in analyzing and describing problems. Each student is required to submit an experimental report. The report of the experiment takes up 15%. In the report, except for displaying the dates they obtain from the experiment and drawing the conclusions from the real experimental process, the students are asked to analyze the experimental system and experimental results. Besides, they are encouraged to propose improvement suggestion for the experiment. Writing laboratory reports can help students to renew their knowledge structure and cultivate their reasonable ability.

Each team will give a presentation to other teams, and the team can get feedback from other teams. This encourages the communication between students and improves their express ability. This part accounts for 15% in the calculation of the final grade.

4. CONCLUSION

Experimental teaching is a main unit of training the practical and creative capacity of students. Taking the photoelectric detector characteristic measurement experiment as the example, this paper introduces a new experimental teaching mode to issue the problems in the traditional experimental teaching. In the proposed teaching mode, the two different-level experimental contents meet the needs of personality development for students, while the student-centered heuristic experimental teaching method greatly stimulates students' enthusiasm and initiative. Besides, the multifaceted experimental evaluation is adopted to test the students' mastery theory knowledge, practical ability, innovative ability, interpersonal skills and express ability comprehensively. Practice over a period of two years shows that, the new experimental teaching mode can cultivate students' quality better than the traditional experimental teaching.

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