On "Stratified and Progressive" Teaching System of College Physics Experiment Course

Xiaoying Wang[1, a *], Hua Zhang[1,b], Dangshe Wang[1,c]

[1] School of Freshmen, Xi'an Technological University,

Xi'an, 710021, Shaanxi Province, China

[a *]email: 2575899328@qq.com, [b]441506840@qq.com, [c]522845826@qq.com

Abstract. Improving the teaching quality of College Physics Experiment Course can make it conducive to cultivating students' practical ability and innovative thinking ability. In view of the basic teaching requirements for this course, its current curriculum, teaching status and existing problems in domestic colleges and universities are analyzed. In accordance with the present background of the rapid development of science and technology informatization, the paper proposes a "stratified and progressive" teaching system of college physics experiment, and discusses its teaching contents, teaching resources, teaching model and course evaluation. Therefore, as for the actual situation of our university, the construction steps and ideas for this course have been given.

Keywords: College physics experiment course; Curriculum system; Stratified and progressive

1. Introduction

With the rapid development of science and technology, the methods and tools for humans to understand and transform the world continue to expand, and knowledge production and dissemination have undergone tremendous changes. This is mainly reflected in the following facts. On the one hand, the change of disciplinary knowledge is accelerating, which has had an impact on the traditional disciplinary system and teaching system to some extent [1]; on the other hand, the channels for knowledge dissemination are diversified. Especially the development of the Internet in recent years makes network and multimedia technology more deeply integrated into the path of knowledge dissemination [2, 3]. As society's demand for talents continues to increase, higher requirements are placed especially on the innovation ability and personality development of college students. College Physics Experiment Course, as a compulsory foundation course for basic training of students in scientific experiments in higher science and engineering colleges, is regarded as the beginning of receiving systematic experimental methods and experimental skills training for undergraduates. Thus, its teaching contents and methods are bound to confront with reforms and challenges.。 In domestic colleges and universities, College Physics Experiment Course is an independent one, covering mechanics, heat, electromagnetism, optics, and modern physics. With rapid development of science and technology, this paper intends to explore the construction of a "stratified and progressive" teaching system of College Physics Experiment Course in order to cultivate students' innovative thinking and practical abilities.

2. Basic Situation of College Physics Experiment Course

College Physics Experiment Course in domestic universities generally offers about 20 experimental projects, which are bound to be completed in two semesters. These projects include both basic experiments and comprehensive ones. In some first-class universities, design or research experiments are offered [4, 5]. However, most of them are only provided to a small number of outstanding students as electives. Their conventional teaching methods involve the following ones. (1) Students preview before class so as to understand the experimental principles, experimental contents and procedures. Then they will write a preview report; (2) Students in class conduct experimental operations, which means that they will fulfill the specified experimental content in the prescribed time. Meanwhile, the teacher will demonstrate the operation and guidance, and answer

students' questions; (3) After class, students will process the data and complete the experimental report. After completion of these three conventional links, students accomplish the experimental projects and contents step by step. For most students, these teaching methods lead students to focus on completing the experiment within the specified time in the laboratory. Therefore, they can only obtain the required data according to the experimental steps described in the experimental instruction book, which can help them finish the corresponding experimental content. So, students rarely reflect or ask questions.

In recent years, many domestic universities have carried out online practical teaching in different ways and to varying degrees, such as conducting virtual simulation experiments, home experiments, etc. [6, 7]. At the same time, they have also constructed some practical teaching resources on the Internet teaching platform. The application of Internet and modern media technology in practical teaching provides a good start and demonstration effect [8-10].

3. Current Problems of College Physics Experiment Course

3.1 Insufficient Support of the Curriculum System for the Sustainable Development of Students in Different Majors and at Different Levels. In most universities, College Physics Experiment Course, offered in two semesters, show no concern to the differences between students' majors and levels. That is to say, students of different majors and levels will complete the same experimental contents. Obviously, this traditional curriculum system and teaching methods do not pay enough attention to their differences, and cannot meet their learning and training needs. This compels its curriculum system, contents arrangements and teaching methods to be changed. As for the characteristics of students' majors and their actual situation, the practical ability training related to their major should be strengthened. The experimental projects at different levels and required abilities should be designed to gradually improve students' inquiry ability, practical application ability and innovation ability. However, the traditional teaching of College Physics Experiment Course is difficult to take into account such differences among students and professional categories.

3.2 Weak Connection between the Advancement of Teaching Contents and Society's Requirements for Talents. Under the traditional concept of talent training, the basic knowledge and ability training is the focus, and the contents of College Physics Experiment Course are also the same in colleges and universities. What's more, the experimental projects are divided into basic experiments and comprehensive experiments, which lack of designed experiments and research experiments. This has resulted in the fact that most experimental projects, experimental instruments, Measurement methods, experimental methods and experimental techniques only cater for fundamental training, which cannot reflect the development of the times and the achievements of scientific and technological progress in a timely manner, and cannot keep up with the rhythm of the times. In particular, there are serious deficiencies in the application of computers and sensors for intelligent data collection, general software processing of experimental data, digital experimental processes and results, and modern physical experimental technology.

3.3 Less Effective Training of the Teaching Model in Cultivating Students' Innovative Ability and Physical Experiment Literacy. Generally speaking, the teaching of experimental courses in colleges and universities adopts the offline teaching mode, that is, the prescribed experimental teaching content is completed in the prescribed time and laboratory in accordance with the given complete set of experimental equipment. In this mode, students can only accomplish the experimental content and measure the data required based on the instructor's explanation and demonstration in compliance with the experimental procedures in the textbook. Therefore, this teaching model limits students' thinking, making students not only unable to fully understand the physical principles of experimental instruments, but also unable and unwilling to understand where these experimental instruments can be applied, let alone consider why these experiments are designed in this way, whether there are other options and what factors will affect the experimental results. Obviously, the kind of teaching model is not effective in cultivating students' innovative ability and physical experiment literacy.

4. Constructing the Teaching System of College Physics Experimental Course

Nowadays, college students have grown up in the surroundings of Information Technology Development, their level of mastering and understanding information technology is relatively high, which provides a good foundation and thinking for the reform of the teaching system of college physics experimental courses. At the same time, the implementation of the "student-centered" educational concept in higher education has been put forward. On the basis of consolidating students' mastery and application of basic measurement methods, experimental methods, and experimental skills, the new concept focus on cultivating students' scientific thinking and innovation awareness, improving students' analytical abilities, design ability and innovative ability, and strengthening students' scientific literacy, which lay a good foundation for students to carry out subsequent scientific experiments.

In view of the current characteristics of students in colleges and universities who have a high level of mastering and understanding Information Technology, combined with the training objectives of different major categories and the individual development needs of students at different levels, the teaching contents should be built based on constructing a "stratified and progressive" teaching model. Meanwhile, a full play should be given to the role of the online teaching platform and offline experimental platform so as to form a high-quality mixture of online and offline practical course system, which can not only effectively use information-based teaching methods, but also is beneficial to students' sustainable development.

4.1 Building Teaching Contents of the "Stratified and Progressive" College Physics Experimental Course. According to the *Basic Requirements for Teaching Physics Experiment Courses in Science and Engineering Universities* formulated by the Teaching Steering Committee of the Ministry of Education[11], the contents of College Physics Experiment Course are involved into four levels: basic experiments, comprehensive experiments, designed experiments and research-based experiments. Their contents are gradually deepened and improved hierarchically.

4.1.1 Basic Experiments. It is open to all students majoring in science and engineering in the colleges, and its contents are the same for all majors. The experimental contents mainly cover the measurement of basic physical quantities, the use of basic instruments and the training of basic experimental skills. In addition, the basic measurement methods, errors and uncertainties, and data processing theories and methods are included. Such experiments can help students master basic measurement methods and experimental skills so as to correctly process experimental data and the ability to write qualified experimental reports.

4.1.2 Comprehensive Experiment. As for students' different majors in different science and engineering fields, these experiments will designate different modules on the basis of their professional requirements. The experimental contents involve multiple knowledge fields in mechanics, thermal science, electromagnetism, optics, modern physics, etc. in an experimental project, and a variety of experimental methods and technologies should be applied comprehensively. Through such experiments, students' learning achievements in the basic experimental stage can be consolidated, and students' horizons and ideas can be broadened. Consequently students' ability to comprehensively apply experimental methods and experimental techniques can be improved.

4.1.3 Design Experiments. Students from different science and engineering majors can form teams according to their own abilities and needs, and select an experimental project which conforms to their level to complete. The experimental contents provide the experimental title, requirements and experimental conditions, and students are expected to design their own plans and complete the entire experiment process independently. The main purpose of these experiments is to cultivate students' ability to employ the theoretical knowledge, experimental methods and experimental techniques they have learned, and to complete the experimental plan design in combination with the given conditions, and the experimental operation relatively independently.

4.1.4 Design Experiments. As for students who are willing and capable of further learning, students can complete experimental research projects alone or in teams. Students are required to conduct these experiments in a scientific research manner around a given topic. They aim to assist students to acknowledge the whole process of scientific experiments, gradually master scientific

ideas and methods. Therefore, students' ability to conduct independent experiments and apply the knowledge they have learned to solve given practical problems can be fostered.

4.2 Exploring the Teaching Mode of "Stratified and Progressive" College Physics Experimental Course. In order to better implement the "student-centered" educational concept and effectively convey the teaching content of “Stratified and Progressive” College Physics Experimental Course, it is necessary to modify the teaching model. On the basis of focusing on the three links including before class, in-class and after class, the teacher should give full play to the online teaching platform and offline experimental platform. On the one hand, this requires establishing and improving online teaching materials for different levels of experimental contents, and preparing sufficient offline experimental instruments and accessories; on the other hand, different teaching models should be adopted according to different levels of experimental contents.

The basic experiments and comprehensive experiments require to establish and improve the collection and editing of relevant experimental videos and background information on the online teaching platform. During the teaching, students are required to combine the experimental teaching materials before the experiment and learn through the online teaching platform to understand the background of the experimental project, the structural performance of the experimental instrument, the correct operation method of the experimental instrument, and the application of the experiment in modern technology. Moreover, students can complete the Q&A session after online learning. In offline experimental classes, students enter the laboratory to become familiar with the instruments and then operate the experimental instruments; during the experiment, teachers provide guidance and answer students' questions at any time, complete the experiment content, and record measurement data. After the experimental class, students process experimental data, analyze experimental errors and their causes, and finally complete experimental reports.

As per the design experiments and research experiments, there is no need to collect and edit materials related to the experimental topics for the construction of online teaching platforms; instead, they focus on the application or embodiment of different physical principles in experimental measurements, the characteristics of different experimental measurement methods, their advantages and disadvantages, as well as the introduction and manifestation of the structural performance, and operating methods of the existing laboratory instruments and equipment. Before class, students are required to collect and review literature through online platforms independently, understand the experimental questions and the research requirements and contents, so that they can propose experimental design plans. In addition, they can also discuss with the experimental instructor through online virtual classes, and finally are permitted to enter into the laboratory when their preliminary experimental plan is accepter. Their preliminary experimental attempts in offline experimental classes can perfect their experimental plan in order to fulfil the experimental research. After class, students process experimental data, analyze experimental errors and their causes, and finally complete experimental reports.

4.3 Formulating the Evaluation System of the "Stratified and Progressive" College Physics Experimental Course. Course assessment and evaluation is to test students’ learning outcomes and the teaching effectiveness of experimental courses. College Physics Experiment Course is composed of various experimental projects at different levels. When experiments at different levels adopt a blended teaching model, their teaching objectives at each level are different, so are the teaching methods. Therefore, the assessment indicators should be different.

As far as the basic and comprehensive experiments, assessment and evaluation can take the following aspects into account, such as students' completion of tasks in online learning, performance in question-and-answer sessions, as well as offline operations and the quality of experimental report writing.

As to designed experiments and research experiments, the instructor is not required to keep an eye on every step of the students' experimental research process, and the experimental tasks could be finished by a team of students. Thus, it is impossible to objectively assess an individual student's practical experimental research capabilities based on their research reports. Consequently, the evaluation of designed experiments and research experiments should be different from those of

basic and comprehensive experiments. The combination of instructor evaluation, student self-evaluation, student mutual evaluation, etc. should be harnessed. And the final scores should be worked out based on their respective weights.

5. Thoughts on the Reform of College Physics Experimental Course at XATU

In the context of the times and society, Xi'an Technological University sets its talent training goal. Combined with the *Basic Requirements for Teaching Physics Experiment Courses in Science and Engineering Universities* issued by Teaching Guiding Committee of the Ministry of Education[1], teachers of Physics Experimental Course make full use of network technology, multimedia, modern educational technology and rich teaching resources to solve the teaching pain points. One of the approaches is to implement the "Stratified and Progressive" College Physics Experimental Course and develop a blended teaching model. In order to achieve efficiency, the teaching contents and the existing resources in laboratories should be re-arranged and sorted out. In the subsequent process, the laboratory construction will be carried out according to the contents and the teaching model of the "Stratified and Progressive" experimental course.

5.1 Developing Experimental Projects. The contents of College Physics Experiment Course are composed of experimental projects. Its reform mainly focuses on the knowledge, ability, and quality goals. According to the experimental teaching contents, the experimental projects should be layered from the perspective of difficulty, namely including basic experiments, comprehensive experiments, design experiments and research experiments. The purpose is to train students' skills to operating basic physical instruments, comprehensive analysis and problem-solving abilities, innovative thinking and practical abilities so that their physical literacy and emotions could be improved.

In summary, existing experimental projects must be sorted out, and instruments with good performance and operating conditions, as well as the highly advanced ones, must be retained in accordance with their hierarchical categories. Then, combined with the characteristics of professional talent training, we should replenish experimental instruments that can reflect the development of the times and the achievements of scientific progress, especially the latest and most advanced instruments, experimental methods and experimental technologies. Meanwhile, teachers are organized to develop comprehensive and design experimental projects that are highly relevant to the corresponding professional knowledge or disciplines on the basis of the experimental instruments, Finally, we developed exploratory experimental topics based on previous projects in the competitions, such as Chinese College Students Physics Experiment Competition, Chinese College Students Academic Competition, and "Internet+" College Students Innovation and Entrepreneurship Competition.

5.2 Supplementing Teaching Resources. High-quality blended teaching requires high-quality resources. Firstly, existing resources should be supplemented and improved. These include experimental courseware, micro-course videos, videos explaining the structure and performance of instruments and equipment, ideological and political cases, question banks, etc. The material-based questions could be added to the question bank, which should contain cutting-edge knowledge, hot spots and development of science and technology, which can reflect ideological and political elements related to technological power, national pride and great power image. Secondly, the historical materials and the application of physical experiments in modern science and technology should be collected. Studying historical materials of physics experiments can help students understand the development process, basic concepts and experimental methods of physics, which will help students better comprehend the nature and ideas of physics and improve students' cognitive level of physics. Mastering the application of physical experiments in modern science and technology can stimulate students' interest in learning, cultivate students' scientific literacy and innovative thinking, so that they can experience the impact of physical experiments on the development of science and technology and society.

5.3 Implementing Diversified Evaluations. College Physics Experimental Courses adopts a blended teaching model, which involves a wide range of teaching activities and each student generates different outcomes. Therefore, the assessment of each experimental project completed by

students should be a multi-dimensional. The assessment of the basic and comprehensive experiments should quantify the online learning feedback, experimental operation, and experimental report to form a comprehensive score. The evaluation of design and research experiments should quantify the instructor evaluation, student self-evaluation, student mutual evaluation to form a comprehensive score. The overall score of the course is finally given by a weighted synthesis of each experimental project and the final exam.

6. Summary

To sum up, the teaching contents of a "Stratified and Progressive" College Physics Experiment Course and the sufficient employment of laboratory instruments and equipment are conducive to the talent cultivation of students in different majors, and taking into account the individual differences of students. In the era of rapid development of modern information technology, the use of diversified information teaching content and methods and the implementation of blended teaching models can effectively combine online teaching resources with practical training in offline experimental classes. So the advantages of both promote students to achieve high-efficiency in learning; it is also conducive to cultivating students' basic scientific experimental skills, scientific thinking and innovation consciousness. Meanwhile, students' analytical ability, innovation ability and scientific literacy could be progressed.

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