Explore application of hierarchical approach in College physics experiment teaching

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Abstract

College physics experiment teaching is different from the general theoretical knowledge teaching, which emphasizes students' practical ability and logical thinking ability in experimental design. The traditional teaching approach still has shortcomings in the cultivation of students' interest in experiment, and meanwhile, it is not conductive for the improvement of students' learning interest in experimental course. The hierarchical teaching approach proposed achieves the division of teaching contents according to certain layers, so it can be used to implement teaching in different stages according to students' acceptance of knowledge complexity. Compared with traditional teaching mode, hierarchical teaching enhances students' ability to understand knowledge and enables them to accept the knowledge implanted by teachers and to study in a progressive and gradual manner according to knowledge mastered. By applying the hierarchical approach in experimental teaching, teachers not only achieve the continuity and consolidation of theoretical knowledge, but also largely enhance the scientific literacy of college students.

Keywords: hierarchical teaching, college physics, experiment teaching, application

1 Introduction

In the implementation of specific experimental course, teachers can adopt the hierarchical teaching approach for different courses and different students. Teachers can make students who grasp theories better to explain relatively easy contents of experiential theory, then let students with strong absorption ability to carry out appropriate operations, and arrange the rest students for summarization and records, thus achieving the re-hierarchy of students and meeting the needs of actual experimental teaching [1-4]. Therefore, teachers can achieve better teaching achievements. In addition, the implementation of this teaching approach promotes the students' learning interest in experimental course, ensures their active participation in classroom teaching, and exercises their sense of innovation and independent operating ability [5-8]. Compared with traditional teaching approaches with some drawbacks, hierarchical teaching approach is advanced and scientific in addition to effectively removing these drawbacks. In combination of some specific teaching examples and for the actual application of hierarchical teaching approach in college physics experiment teaching, this paper makes the following analysis and discussion.

2 Drawbacks in traditional college physics experiment teaching

Traditional college physics experiment teaching mode is a set of procedures: firstly, teachers explain experimental objective, principles and tasks as well as experimental precautions; secondly, students carry out repeated operations of specific experiment according to experimental theory and experiment process explained by teachers, and make records and repeated validation of data obtained through measurement in the experimental process. This traditional model has been applied in the teaching of most Chinese universities and colleges for many years. The experimental performance evaluated includes usual performance, midterm performance and final performance. Usual experimental performance involves whether daily attendance and experimental operation are standardized and reasonable and whether the experimental report is completed [9, 10]. There are many methods to evaluate final performance, for instance, the school organizes closed-book exams; teachers design some specific experimental operations, from which students select the appropriate ones. In this way, students' experimental operation level and their ability to understand experimental contents are evaluated.

In general, traditional teaching approach is to teach students the specific operating methods of laboratory instruments, and help them understand the specific experimental skills and methods to measure data. This approach has been used for many years. However, with the continuous social development and in combination of actual working situation of students after graduation, this teaching approach has been gradually unable to meet the social demands for experimental talents, and it is too old in contents. Meanwhile, the way to evaluate student's performance is slightly simple, so that student's interest in learning and enthusiasm of participation in experiment cannot be stimulated. The traditional teaching approach excessively focuses on teacher's core role in the experimental teaching, ignores students' specific experience and initiative, and makes students develop bad habits, such as following teacher's requirements, copying textbook knowledge and repeatedly operating experimental contents. These are not conducive to social actual demands for experimental talents and the effective development of students' creativity.

3 Reflection of hierarchical approach in college physics experiment teaching

In college physics course, the aim to carry out experimental teaching is mainly to develop students' practical operating ability and creativity in experimental design. The experimental teaching is an important stage in the cultivation of student's comprehensive quality. However, the traditional teaching model lays too much emphasis on the teaching of theoretical knowledge as well as principles and skills of verification test, but ignores the cultivation of students' independent work ability as well as scientific literacy. Therefore, in order to meet the real needs of social development for experimental talents, it is imperative to reform the experimental teaching approach. The reform goal should be based on conformance to era development. In the teaching process, it is necessary to pay attention to students' dominant role, stimulate their thinking vitality and learning enthusiasm, and finally improve their comprehensive quality, thus enabling them to really adapt to current social development situation. Meanwhile, it is the spirit and instruction issued by education sector in terms of university work. Therefore, a new hierarchical teaching model becomes more advanced and efficient in the experimental teaching. In college physics experiment teaching, the hierarchical teaching approach can be adopted from the following three aspects.

3.1 HIERARCHICAL TEACHING FOR EXPERIMENTAL THEORETICAL KNOWLEDGE

In college physics experiment teaching, the vast majority of guiding theories and basic knowledge applied in textbooks are uniformly compiled in the first chapter and introduction of textbooks, mainly involving analysis of errors in the experiment and processing of experimental data. Solving these problems needs combining statistics, probability, calculus science and other theories. However, for the freshmen in university, they have not been exposed to many contents. Thus, they cannot have a better understanding and acceptance of data processing and error analysis. In this case, while explaining theoretical knowledge, teachers should combine the specific situation and carry out hierarchical processing of teaching contents and teaching order for theoretical knowledge.

When teaching students experimental theoretical knowledge, teachers can follow several layers below.

3.1.1 First layer

The content in the first layer should be simple according to the actual situation, so that freshmen are easy to accept the contents. The contents can include brief introduction to effects, tasks, position and basic procedures of experimental course. Meanwhile, in this layer, it is necessary to cover the brief introduction to tests in subsequent experimental courses, enabling students to have a general understanding of subsequent experiments, and enhancing students' learning interest in physics experiment course.

3.1.2 Second layer

The second layer should be progressive based on the first layer. In the beginning, the second layer involves some general knowledge in the experimental process. The contents can include simple ways to estimate experimental errors and application of effective number in the experimental data. The teaching contents in the second layer can be carried out simultaneously with simple experimental operations, so that students can have an intuitive understanding and experience of measurement methods involved through simple experimental operations. For data obtained through measurement, the effective number can be estimated. For instance, when conducting the experiment of length measurement, teachers can directly tell students the formula of error propagation, and let them apply in the experiment, so that students can sensitively understand the knowledge of error propagation and learn to process simple error data. As for formula, teachers can arrange homework to students and let them make deduction. On the one hand, it enables students to have a deeper understanding of the use of formula; on the other hand, it greatly improves the efficiency of classroom teaching and saves teaching time.

3.1.3 Third layer

This layer mainly involves the processing of data collected in the experimental process. The experimental course standards in the college physics course require students to master and use the processing of data obtained through differential method, graphic method and list method. When explaining knowledge in this layer, teachers can conduct basic experiments at the same time. Through data processing in the specific experimental process, teachers can bring vivid and intuitive expression to students, so that students can grasp the data processing methods easily and the teaching effect will become better. For example: in the experimental measurement of elastic Young's modulus of metal wire with the tensile method, teachers can explain the method of successive minus among data processing methods layer by layer and step by step in the experimental process.

3.2 HIERARCHICAL TEACHING FOR EXPERIMENTAL OPERATION KNOWLEDGE

For experimental operation, the learning effect of each student is different, which, on the one hand, is affected by the mastery extent of theoretical knowledge; on the other hand, is affected by students' operational ability. According to the difficulty of experimental operation and teaching objectives, the teaching in this phase can be divided as follows.

TABLE 1 Teaching phases

	Basic phase	Improvement phase	Design phase
Teaching objectives	Carry out systematic training on basic measurement means and experimental skills, aiming to cultivate students' ability to analyze error and ability to process data, and lay a strong foundation for subsequent specific experimental teaching.	Further consolidate learning results in the last phase, improve students' ideas of experimental operation and comprehensive use of related technologies and methods	Combine experimental application in real life and cultivate students' operational ability and ability to independently design experiments.
Teaching contents	1. Measurement of physical quality and length 2. Measurement of liquid viscosity 3. Measurement of linear expansion coefficient 4. Measurement of Young's modulus 5. Measurement of moment of inertia 6. Oscilloscope usage 7. Method to measure electric resistance with electrical bridge 8. Volt-ampere characteristics of diode 9. Deflection and focusing of electron beam 10. Measurement of electromotive force with potential difference meter 11. Phenomenon of optical interference 12. Phenomenon of optical polarization 13. Adjustment and use of spectrophotometer 14. Measurement of refractive index of light 15. Measurement of Planck constant according to photoelectric effect	1. Measurement of sound velocity 2. Measurement of spectral line wavelength of mercury lamp by transmission grating 3. Milligan oil drop experiment 4. Ultrasonic flaw detection 5. Measurement of electrostrictive coefficient 6. Measurement of electric resistance and calibration of electricity meter by potential difference meter 7. Fourier transform spectroscopy experiment 8. Sensor test 9. Measurement of object thickness according to automatic ellipse polarization effect 10. Holography 11. Frank - Hertz experiment 12. Acousto-optical effect	1. Installation of digital meter 2. Study of simple harmonic motion 3. Study of acceleration of gravity 4. Measurement of resistivity of electric wire 5. Relationship between wavelength and refractive index 6. Study of circuit control by rheostat 7. Study of resonance characteristics of LRC circuit 8. Study of transient process of LRC circuit 9. Relationship between the angle of incidence and the angle of deflection when the light wave goes through the triple prism

For these layers above, analysis will be conducted with one specific experiment: the fourth experiment in the design phase – measurement of resistivity of electric wire. If students want to measure the specific resistivity of electric wire, they need the length, diameter and resistance of electric wire. The diameter and resistance can be directly measured. The electric wire is like a spiral, so the length cannot be directly measured, but can be measured by the volume formula. There are many methods to measure the length and resistance in the physics experiments. Teachers can set up tasks to allow students to design their own experiments and choose a method to measure the length and resistance. In this way, the normal classroom is ensured on the one hand and students' divergent thinking and innovation capabilities are cultivated on the other hand.

There are several methods to measure the length of electrical wire, shown as follows.

3.2.1 Measuring cylinder

Put a certain amount of water in a measuring cylinder, and immerse the electric stove wire in the water. Wherein, the inner diameter of cylinder is r. Measure the change in water height Δh . The volume and length of the wire can be obtained according to the following formulas.

$$V = \pi r^2 \Delta h,\ L = \frac{4r^2 \Delta h}{d^2}. \tag{1}$$

3.2.2 Spring scale

Hang the electric stove wire on the spring with the stiffness coefficient k. Separately, measure the stretching amount of spring in the air and in the water, h and h1. According to Archimedes' principle and Hooke's law:

$$\rho_0 V g = k(h - h_1),\ mg = kh. \tag{2}$$

Therefore, the volume and length of the electric stove wire are respectively:

$$V = \frac{m(h - h_1)}{\rho_0 h},\ L = \frac{4m(h - h_1)}{\pi d^2 \rho_0 h}. \tag{3}$$

3.3 HIERARCHICAL TEACHING FOR PARTICIPANTS IN EXPERIMENT-- "STUDENTS"

Physics experiment course is designed for all students in college, while students in different majors are different in entrance performance and mastery of specific subjects. Students in some majors prefer theoretical knowledge and students in other majors have stronger practical ability. For experiments in a layer, in usual, there are many experiments carried out at the same time but they are still greatly different in the complexity and contents. When adopting hierarchical teaching approach, teachers can divide students in the experimental course into two layers according to the above specific situation. For students with a relatively poor foundation, teachers can let them implement relatively easy and simple experimental items; for students with strong abilities, teachers can let them implement relatively difficult experimental items. With the hierarchical teaching according to students' specific situations, students' active learning interest and enthusiasm of participation in experimental course can be largely promoted.

4 Conclusion

In conclusion, the implementation of hierarchical teaching approach in college physics experiment teaching enables teachers to have clearer teaching ideas on the one hand, and

better achieves the individualized education program on the other hand. It promotes student' learning interest in experimental courses, ensures students' active participation in classroom teaching and meanwhile, exercises students' sense of innovation and independent operating ability. It allows students to get a great mental exercise and enables students to be better devoted to the actual physics experiment teaching. It is of positive significance to the promotion of quality of experimental results and experimental speed. The systematic and comprehensive in-depth reform of college physics experiment teaching is a long-term project, not only requiring the active participation of teachers, but also requiring initiative cooperation of students. Only with the joint participation of both students and teachers, can the simultaneous development of students' knowledge application ability and experimental skills be ensured. As an advanced teaching mode, hierarchical teaching approach is bound to be more widely applied in the teaching of various subject in university in the future.

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