Research on the reform of college physics experiment teaching under the cultivation of innovative talents

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Abstract: Cultivating innovative talents is the main goal of college physics experiment teaching reform, which is helpful to assist students to master the idea of solving physics problems more clearly, to be familiar with physical concepts, to improve students' ability of physics experiment and knowledge practice, and to stimulate students' creative potential. This paper gives some examples on the reform of college physics experiment teaching under the cultivation of innovative talents, and puts forward some personal opinions.

1. Introduction

In 2010, the Ministry of Education issued the outline of the National medium and long term Education Reform and Development Plan (2010-2020), pointing out that the core goal is to train innovative talents and improve teaching quality. For college physics, to realize the goal of cultivating innovative talents, we must integrate theory with practice, organize the interaction of open experiment teaching on a regular basis, set up the demonstration laboratories, and use network technology to construct physics experiment teaching platform.

2. Integration of theory and practice teaching mode

The integrated teaching mode of theory and practice is to let students do relevant experiments while explaining the theoretical knowledge of physics, and continuously improve the level of theoretical knowledge and practical ability. In addition, the integrated teaching mode of theory and practice is based on the principle of " innovation, practicality, standardization and science", that is, cultivating students' innovative thinking in teaching activities, improving the practicality of physics teaching, standardizing students' learning behaviors and experimental methods, and shaping students' scientific research spirit. On the other hand, the integrated teaching mode of theory and practice adheres to the principle of " moderation". Whether it is to explain theoretical knowledge or carry out experimental activities, it pays attention to moderation, it will not teach theoretical knowledge for a long time or let students do experiments all the time. instead, it will combine theoretical teaching with experimental activities, thus effectively improving the teaching effect [1]. At the same time, teachers will strengthen the experimental teaching effect by promoting exercise training to improve the students' ability to use theoretical knowledge and enhance the comprehensive effect of physics experiment teaching. For example, when explaining "curvilinear motion", teachers will integrate mathematical elements, let students use compasses to draw circles, and guide students to realize that circle movement is a typical circular motion, and is closely related to daily life, it is the specific application of Newton's second law and kinematics, and can examine the comprehensive analysis ability and logical thinking ability. The examination of circular motion in physical exercises is generally divided into two categories. The first category is to examine the basic laws of circular motion, such as the relationship between linear velocity, angular velocity and cycle, and the second is to examine the force analysis, centripetal force formula and dynamic equation, through the scene of fine rope, light rod, turntable and track.

Physics is an experimental subject, and the general goal of the subject education is to improve the students' experimental ability. Therefore, in the process of carrying out college physics teaching activities, teachers should combine the general goal, guide students to participate in experimental activities actively and experience the knowledge of physical concepts. For example, in explaining

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the "law of gas experiment," students are first guided to recognize the conceptual knowledge of isothermal changes, isochoric changes and isobaric changes, and multimedia courseware is used to inform students that isothermal change is a certain gas of certain quality, and the pressure changes with volume under the condition of constant temperature; The isochoric change is the change of a certain mass of gas pressure with temperature when the volume is constant; The isobaric change is the change of a certain mass of gas volume with temperature when the pressure is constant. Then, the teacher can let the student know the law of isothermal changes, isochoric changes and isobaric changes from the angle of Boyle's law, Charles's Law and UosephLollis Gay—lussac. The law of isothermal change means that the pressure of a certain mass of gas is inversely proportional to its volume under the condition of constant temperature. The law of isochoric change means that the pressure of a certain mass of gas is inversely proportional to its temperature under the condition of constant volume. The law of isobaric change means that the volume of a certain mass of gas is inversely proportional to its temperature under the condition of constant pressure. Then, teachers and students can calculate the pressure of the closed gas through experiments. In experimental teaching activities, teachers can use the following three methods:

（1）Reference liquid level method

① The main basis of calculation is the knowledge of fluid mechanics. The pressure generated by liquid gravity in the depth of h below the liquid level is $p=p$gh. It is important to note that h is the vertical height of the liquid, which is not necessarily equal to the length of the liquid column. If the liquid level is in contact with the external atmosphere, the pressure at h below the liquid level is $p=p_0+p$gh and p_0 is the external atmospheric pressure. The Pascal's law used in the experiment is also the law of the liquid transferring the applied pressure, its main content is that the pressure applied to the closed static liquid can be transferred from liquid to every direction without change. The principle of connectors in experiments is that the pressure on the same horizontal plane of the same liquid (intermediate liquid uninterrupted) is equal in the connectors.

② The calculation method has four processes. First, select a hypothetical liquid thin surface (its weight does not count) as the research object; Secondly, analyze the force on both sides of the liquid surface through experiments and establish a force balance equation; Thirdly, eliminating the cross-sectional area to obtain the pressure balance equation on both sides of the liquid surface; Fourth, calculate the gas pressure.

（2）Balancing method

In order to obtain the gas pressure of solid or liquid enclosed in a static container, the solid (e.g. piston, etc. .) or liquid that is in contact with the enclosed gas is usually selected to carry out force analysis, including the gravity of the object, the pressure of the internal and external gases, and so on. then, it is solved according to the equilibrium condition of the force.

（3）Dynamic method

When the system in which the closed gas is located is in a mechanical non-equilibrium state, in order to obtain the pressure of the closed gas, first you must properly select the object (e.g. liquid column, solid, etc. associated with gas), analyze its stress correctly (pay special attention to analyzing the pressure of internal and external gases.), and then apply Newton's second law to solve the equation.

In addition, teachers can combine physical problems with experimental activities, encourage students to innovate in the process of solving problems, learn to simplify complex problems. For example, ask the student if the cylinder or piston is separated into two parts of gas, when the temperature of the gas changes, is the liquid column or piston moving? After the student has answered the question, the teacher can make a summary and tell the student that the characteristic of this kind of question is that the state of the gas p, V, T has changed, so it is more difficult to directly judge the moving direction of the liquid column or piston. We usually do experiments to first assume the state of the gas, and then we use Charlie's law to solve it simply. The general analytical idea is to first assume that the liquid column or piston does not move and that the two parts of the gas change in equal volume, and then apply the Charley's law to solve the pressure change of each part of the gas, and compare the two parts of the gas pressure. This can not only help

students master the idea of solving problems and improve their experimental skills, but also stimulate students' innovative consciousness on the basis of it.

3. Organize the interaction of Open experiment Teaching on a regular basis

Based on the goal of cultivating innovative talents, one college of physics has drawn up an experimental teaching plan, which divides the physics experiment curriculum into the following five modules:

First, the basic knowledge of experiments and the use of basic instruments. The module can be divided into eight parts, that is, error and effective number, main idea and method of experiment, processing method of experiment data, instrument for measuring length, instrument for measuring time, instrument for measuring current and voltage, instrument for adjusting resistance, and multi-purpose electricity meter.

Second, mechanical experiment module. The module has seven parts, which are respectively to study the linear motion of uniform speed change, to explore the relationship between spring elasticity and elongation, to verify the parallelogram rule of force, to verify Newton's law of motion, to explore kinetic energy theorem, to verify the conservation law of mechanical energy, and to verify the conservation law of momentum.

Third, electrical experiment module. That is measuring metal resistivity, drawing volt-ampere characteristic curve of small bulb, measuring electromotive force and internal resistance of power supply, practicing using multi-purpose meter, and simple application of sensor.

Fourth, test selection experiment module. This module consists of four parts, including oil film method to estimate the size of molecules, exploring the movement of simple pendulum, measuring the acceleration of gravity with simple pendulum, measuring the refractive index of glass, and using double slit interference to measure the wavelength of light.

Fifth, demonstration experiment. The module is composed of five parts, which are mechanical demonstration experiment, electromagnetism demonstration experiment, mechanical vibration and mechanical wave demonstration experiment, optical demonstration experiment and other demonstration experiment.

Then, the teacher should organize the students to design a list of knowledge for the experimental teaching module. For example, when analyzing the " main thought and method of experiments", use the situational teaching method, cooperative learning method and experimental activities to guide students to recognize concepts and examples of cognition equivalence method, control variable method, micro-quantity accumulation method, trace method, amplification method and simulation method, strengthen students' ability to transform theoretical knowledge, improve the quality of experimental teaching, and inform students that equivalence is a method to convert complex (or abstract) physical problems into well-known (or image) physical problems. Then, using various open experimental activities to guide students to understand relevant examples. For example, in the experiment to verify the conservation law of momentum, replace the horizontal velocity of the ball with the horizontal displacement of the ball; In the experiment of drawing equipotential lines on the electric field plane by description method, the electric field is equivalently simulated by current field; In the experiment of verifying the parallelogram rule of force, the effect of force and force is the same to test whether the rule is true or not; In the experiment of the instrument for measuring the small length, the spiral micrometer transforms the small linear displacement into the angular displacement by using the equivalent idea and displays it on the larger circumference. The control variable method is to artificially control the factors or conditions that affect the changing laws of things in the process of researching and solving problems, so that some of the conditions change or do not change according to specific requirements. This method can be used to verify Newton's second law and to study the factors affecting resistance and capacitance. The micro-quantity accumulation method is to accumulate some small quantities that are difficult to measure directly and accurately and then measure them to improve the measurement accuracy. The method of micro-quantity accumulation is to measure some small quantity which is difficult to measure directly and accurately, so as to improve the accuracy of measurement. Commonly used methods

are space accumulation method and time accumulation method. This method can be used when measuring the thickness of a piece of paper, the vibration period of a single pendulum and selecting counting points when processing paper tapes. The trace method is a method of recording the fleeting phenomena, such as position, track and image, so as to measure, compare and study them calmly. In the experiment of setting up paper tape, stroboscopic photos and sand pendulum with a timer, the trace method can be used. The amplification method can be divided into deformation amplification method and optical amplification method. In general, small quantities are not easy to measure or observe, and the measurement error is relatively large. various methods are usually used to amplify them. Cavendish torsion scale, Coulomb torsion scale, observation of small deformation of table top or glass bottle and other experiments need to adopt amplification method. The simulation method is an indirect physical experiment method, which shows the regularity of the prototype by the model similar to the prototype. Usually, in the description of equipotential lines in an electric field, it is necessary to use simulation method to simulate magnetic induction lines with iron filings.

Secondly, the teachers of this university have reformed the traditional physics laboratory, teaching mode and teaching project. According to the teaching content and students' interests, they have designed a variety of experimental projects and published the information of the time, project, mentor and head of the experimental group on CHSI. This will enable students to freely choose the experimental activities they like and understand the contents and operation process of the experimental projects.

Thirdly, the school attaches great importance to the experimental activities of verification, and has consolidated and promoted the experiments of verification, such as measuring density and length, in combination with the contents of physics experiments in middle schools. The purpose of the experiment is to guide students to use Vernier calipers, spiral micrometers, micrometers and physical balance. In the length test experiment, the teacher uploaded the structure, precision, principle, reading method, use method and attention direction of the vernier caliper to the class group file. it was pointed out that the vernier caliper is composed of a ruler body, an inner measuring claw, an outer measuring claw, a vernier, fastening screws, a main ruler and a depth ruler. the precision includes 0.1 mm, 0.05 mm and 0.02 mm, and there is no need to guess. Take 10 small cells on the vernier as an example: the length of 9mm on the vernier is equally divided into 10 small cells, each cell is 0.9 mm, which is 0.1 mm different from the dividing value of the main ruler. When the vernier moves 0.1 mm relative to the main ruler, an engraved line on the vernier is aligned with an engraved line on the main ruler. In principle, the accuracy of vernier calipers depends on the difference between the index value of the vernier and the main ruler, and the accuracy = the index value of the main ruler / the number of grids of the vernier calipers. From the view of reading method, vernier calipers have three reading methods. The first is to read out the whole millimeter number from the position of the zero mark on the swim scale and the position opposite the mark line on the main ruler; The second is to align the n - th scribe line on the vernier with a scribe line on the main ruler and read out the fractional part below the whole millimeter scale; The third is to add the above two data together, that is the length of the object to be measured, which can be expressed as $L=s+n\cdot k$ [2]. In the formula, s is the number of millimeters read on the main ruler, k is the precision of the vernier caliper, and there are three kinds of indexes, namely, the number of millimeters read on the main ruler + 0.1n (precision 0.1 mm, 10 degrees), the number of millimeters read on the main ruler + 0.05 n (precision 0.05 mm, 20 degrees), and the number of millimeters read on the main ruler + 0.02 n (precision 0.02 mm, 50 degrees). The first is to allow the left and right measuring claws to gather together before use, and to select the Vernier caliper that the zero marks of the swim ruler coincide with the zero lines of the main ruler; the second is to measure the length of the general object with the external measuring claw and the internal length of the object such as the aperture, using the inside measuring claw. When measuring the depth of an object, such as a slot or cylinder, use a depth ruler. In the process of experiment, we should pay attention to the accuracy of Vernier caliper before measuring, usually 0.1 mm 0.05mm and 0.02mm; Determine the zero error and its positive and negative, so as to correct the measured value after

measurement; When reading, tighten the fixing screw appropriately after the measuring claw clamps the object to be measured so as not to move the vernier on the main ruler; It is not required to estimate the number of digits at the end of the vernier caliper. in case of misalignment between the scribe line on the vernier caliper and the scribe line of the main ruler, the reading of the scribe line closest to a scribe line of the main ruler shall be selected, and the last digit of the valid digit shall be aligned with the accuracy of the vernier caliper; If a vernier caliper in mm is 10 degrees, the decimal point is followed by a number. A Vernier caliper reading of 20 degrees, two digits after the decimal point, zero or five at the end, and zero in the last place cannot be omitted. A Vernier caliper reading of 50 degrees, two digits after the decimal point and an even number at the last.

4. Set up the demonstration laboratories

The demonstration of physics experiment in university is different from the teaching of physics experiment in middle school. It is not only that teachers operate the experimental process from the platform, let the students watch under the platform, but let the students watch the experimental steps and listen to the experimental lectures in the demonstration laboratory, consolidate knowledge of physics. A university showed students the structure, working conditions, usage and precautions of the electromagnetic striking timer in detail when playing the video lecture " electromagnetic striking timer" in a demonstration laboratory. The electromagnetic striking timer consists of carbon paper, positioning shaft, paper tape, vibrating plate, vibrating needle, limiting hole, permanent magnet, pressing wire column, coil, etc. the working condition is 4 - 6V low voltage AC power supply. The use of electromagnetic beat timer is divided into four steps. First, the paper tape is passed through the limiting hole, and the carbon paper sleeve is placed on the positioning shaft and pressed on the paper tape; Second, the two wires are connected to the two poles of the electromagnetic striking timer, and the other end of the two wires is respectively connected with the two poles of the low-voltage AC power supply (4 to 6V); Third, turn on the switch first, then make the paper tape according to the need of the experiment, the paper tape was laid down a lot of small points; Fourth, turn off the power and remove the tape. In addition, when using the electromagnetic striking timer, the following five items should be paid attention to:

① To connect to the frequency of 50Hz low-voltage AC power supply, not on the low-voltage DC power supply.

② Check the timer before use to make it isochronous. If the period is not stable, the length of the vibrating plate should be adjusted so as to adjust its natural frequency to be the same as that of the power supply, and the length of the vibrating plate should be fixed at the position with the largest amplitude.

③ Adjust the height of the pointer so that it is appropriate and does not loosen, so as to avoid defects such as missing points, ghosting and poor is ochronism on the paper tape and reduce resistance to the paper tape.

④ The timer is designed according to the intermittent mode of operation, and the power supply should be cut off in time when a tape is finished, so as not to burn out the coil because of the excessive current time passing through the coil.

⑤ The friction between the tape and the timer is one of the main reasons for the error in the experiment. Therefore, before the experiment, the first thing to do is to put the correct position of the timer so that the paper tape does not collide with the side wall of the limit hole during the moving process.

In addition, the teacher will let the students demonstrate the experiment. in this process, a student or experimental group will sit on the swivel chair and show the experimental process, methods and results to the whole class, so as to give full play to the students' subjective initiative and cultivate their experimental skills [3].

5. Use network technology to construct physics experiment teaching platform.

In the information age, teachers should make full use of network technology to construct physics experimental teaching platform for students, guide students to actively participate in virtualization experiment activities, and then effectively promote the interaction of college physics experiment teaching and enhance students' interest in participating. Teachers should actively integrate the elements of life, use the network platform to develop the physical experiment teaching process, design the visual teaching situation for the students, let the students browse the theoretical knowledge and experimental process, and recognize the physical principles and laws in life. For example, let students judge the physical knowledge involved in " music fountain", " telephone" and " microphone" when explaining " acoustics". In addition, teachers can guide students to learn to judge the quantitative relationship in exercises during physics problem solving, to operate diligently, and to pay attention to the combination of observation and operation results and theories, thus making the originally abstract and static figure vivid in mind. At the same time, teachers should create vivid physics courseware for students, so that students can understand intuitive knowledge, clarify learning ideas, think about problems according to learning content, and solve problems through drawing, thus effectively stimulating students' practical and creative abilities [4].

6. Conclusion

To sum up, based on the goal of cultivating innovative talents and improving the teaching effect of college physics experiment, teachers should cooperate with their school to correctly use the integrated teaching mode, construct a perfect network teaching platform, and organize the interaction of open experiment teaching, set up the demonstration laboratories, so as to improve students' innovative experimental skills and strengthen students' knowledge level.

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