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Research on Innovative Strategies of Physics Experiment Teaching in Senior High School Based on the Cultivation of Physics Core Literacy

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Abstract: This paper focuses on high school physics experiment teaching based on the cultivation of physics core literacy. Firstly, the connotation of physics core literacy, the characteristics of physics experiment teaching in senior high school and their relationship are expounded, and the problems existing in teaching objectives, contents, methods, evaluation and teachers' literacy are pointed out. Then put forward innovative strategies, including optimizing the design of teaching objectives and running the core literacy elements through the whole process; Innovating teaching content, combining reality with cutting edge; Improve teaching methods and means and make use of modern technology; Improve the evaluation system and consider the process and results; Strengthen the improvement of teachers' professional quality. Through the comprehensive application of these strategies, it is expected to improve the teaching quality and cultivate students' core literacy in physics.

Keywords: senior high school physics; experimental teaching; physical core literacy; teaching innovation strategy

1. Introduction

With the continuous deepening of education reform, cultivating students' core literacy has become a key goal in the field of education. As an important branch of natural science, the cultivation of core literacy of physics is very important for the development of students' scientific thinking and comprehensive ability.

Physics experiment teaching in senior high school is an important part of physics curriculum, which can not only help students understand physics concepts and laws, but also cultivate their practical operation ability and scientific inquiry spirit. However, there are many problems in the traditional physics experiment teaching in senior high schools. Teaching objectives tend to focus on imparting knowledge, but fail to reflect the core literacy of physics; The experimental content is not closely related to real life and lacks interest and practicality; Teachers' demonstration is the main teaching method, and students' participation is low; Teaching evaluation also pays too much attention to the results and ignores the process. These problems restrict the improvement of students' core literacy in physics. Therefore, it is of great practical significance to study the innovative strategies of physics experiment teaching in senior high school based on the cultivation of physics core literacy, which can provide useful reference for the reform and development of physics experiment teaching in senior high school.

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2. An Overview of Physics Core Literacy and Related Theories of Physics Experiment Teaching in Senior High School

2.1. Connotation and Elements of Physics Core Literacy

Physics core literacy is an essential character and key ability that students gradually form in the process of receiving physics education to meet the needs of personal lifelong development and social development. It is a quality with physical discipline characteristics internalized by students through physics learning and an important component of students' scientific literacy [1].

Physical core literacy is mainly composed of four elements: physical concept, scientific thinking, scientific inquiry, scientific attitude and responsibility. Physical concept is the basic understanding of matter, motion and interaction, energy, etc., which is formed from the perspective of physics. It is the refinement and sublimation of physical concepts and laws in the mind. With the concept of physics, students can explain natural phenomena and solve practical problems from the perspective of physics. For example, use the concept of energy conservation to understand the transformation process of various energies in nature [2].

Scientific thinking is a way of understanding the essential attributes, internal laws and relationships of objective things from the perspective of physics, an abstract generalization process of constructing an ideal model based on empirical facts, and an internalization of scientific thinking methods such as analysis, synthesis, reasoning and argumentation. For example, when studying the motion of an object, ignoring secondary factors and constructing a particle model are the embodiment of the ideal model construction in scientific thinking.

Scientific inquiry refers to the ability to ask physical questions, form conjectures and hypotheses, obtain and process information, draw conclusions and explain based on evidence, and communicate, evaluate and reflect on the process and results of scientific inquiry. Through independent inquiry, students design experimental schemes, collect data and analyze results, and gradually improve their scientific inquiry ability.

Scientific attitude and responsibility refers to the inner motivation to explore nature, a rigorous, realistic and persistent scientific attitude, and a sense of responsibility to abide by moral norms, protect the environment and promote sustainable development on the basis of understanding the nature of science and the relationship between science, technology, society and environment [3]. For example, respecting the experimental data and not practicing fraud in the experiment reflects a rigorous and serious scientific attitude.

2.2. Characteristics and Functions of Physics Experiment Teaching in Senior High School

Physics experiment teaching in senior high school has obvious characteristics such as intuition, practicality and inquiry. Intuition means that through experiments, students can directly observe physical phenomena and processes and visualize abstract physical knowledge. For example, in the experiment of Newton's second law, students can intuitively see the movement state changes of the car under different tension and mass, so as to better understand the relationship between acceleration and force and mass.

Practicality emphasizes that students operate experimental instruments by themselves, and carry out experimental design and implementation. In practice, students can not only improve their practical ability, but also deepen their understanding of physical knowledge. For example, in the experiment of assembling circuits, students can master the basic principles and connection methods of circuits by connecting wires and adjusting resistors.

Inquiry encourages students to actively explore the unknown, ask questions and solve problems in experiments. For example, in the experiment to explore the factors affecting the period of a simple pendulum, students can independently design an

experimental scheme to explore the influence of factors such as pendulum length, pendulum ball quality and pendulum angle on the period of a simple pendulum.

Physics experiment teaching in senior high school plays an important role in imparting knowledge, cultivating skills and developing thinking. In terms of knowledge transfer, experiments can help students better understand and master physical concepts and laws. Through the observation and analysis of experimental phenomena, students can combine abstract theoretical knowledge with practical phenomena to deepen their understanding and memory of knowledge [4].

In terms of skills training, experimental teaching can improve students' hands-on operation ability, data processing ability and experimental design ability. In the process of operating experimental instruments, students gradually master the use methods of various instruments; When dealing with experimental data, learn to use mathematical methods to analyze and calculate; When designing the experimental scheme, cultivate innovative thinking and logical reasoning ability [5].

In the aspect of thinking development, experimental teaching can cultivate students' scientific thinking and inquiry spirit. Students need to constantly ask questions, analyze and solve problems in experiments, which is helpful to improve their logical thinking, critical thinking and creative thinking ability.

2.3. The Relationship between Physics Core Literacy and Physics Experiment Teaching in Senior High School

Physics experiment teaching in senior high school is an important way to cultivate students' core literacy in physics. In experimental teaching, students can better form physical concepts through personal experience and operation. For example, in the electromagnetic induction experiment, students can intuitively observe the phenomenon of magnetic electricity generation, thus deepening their understanding of the physical concept of electromagnetic induction.

The cultivation of scientific thinking is also inseparable from experimental teaching. During the experiment, students need to observe, analyze and reason the experimental phenomena, build an ideal model and conduct scientific argumentation. For example, when studying the flat throwing motion, students divide the flat throwing motion into horizontal uniform linear motion and vertical free falling motion through experimental observation and analysis, which fully embodies the application of scientific thinking.

The ability of scientific inquiry is directly exercised and improved in experimental teaching. Students independently ask questions, design experimental schemes, conduct experimental operations, collect and analyze data and draw conclusions in the experiment. The whole process is a complete scientific inquiry process.

The cultivation of scientific attitude and responsibility also runs through the experimental teaching. In the experiment, students need to abide by the experimental rules, respect the experimental data, and cultivate a rigorous and realistic scientific attitude; At the same time, understand the impact of experimental technology on society and environment, and enhance the sense of responsibility for protecting the environment and promoting sustainable development.

Physics core literacy plays an important guiding role in physics experiment teaching in senior high school. It provides a clear direction for the formulation of experimental teaching objectives, which should be determined around the four elements of physical core literacy to ensure the cultivation of students' physical core literacy. In the selection of experimental content, we should pay attention to the connection with the core literacy of physics, and select experimental projects that can cultivate students' physical concepts, scientific thinking, scientific inquiry ability and scientific attitude and responsibility [6]. In the application of teaching methods, we should take the cultivation of core literacy of physics as the starting point, and adopt inquiry-based and cooperative teaching methods

to improve students' participation and initiative and promote the improvement of students' core literacy of physics.

3. Problems Existing in the Cultivation of Core Literacy in Physics Experiment Teaching in Senior High Schools at Present

3.1. Teaching Objectives

In the current high school physics experiment teaching, some teachers don't have a deep understanding of the core literacy of physics, which directly leads to the inaccurate positioning of teaching objectives. Physical core literacy covers many aspects such as physical concept, scientific thinking, scientific inquiry, scientific attitude and responsibility. However, some teachers only regard physics experiment teaching as an auxiliary means to impart knowledge, and limit the teaching goal to let students master the experimental operation steps and remember the experimental conclusions, while ignoring the comprehensive cultivation of students' physical core literacy.

For example, in the experiment of "exploring the relationship between acceleration and force and mass", some teachers may only pay attention to let students learn how to operate experimental instruments, record experimental data, and draw the conclusion that acceleration is directly proportional to force and inversely proportional to mass, without guiding students to think about the physical concepts behind the experiment, such as the relationship between force and motion, and the scientific thinking of controlling variables.

At the same time, the teaching objectives are not comprehensive and specific enough to reflect the elements of core literacy. Many teaching objectives only refer to cultivating students' experimental ability in general, but there is a lack of clear elaboration and targeted design on how to cultivate students' core literacy elements such as physical concept, scientific thinking, scientific inquiry and scientific attitude and responsibility in experimental teaching. This makes it difficult for teachers to truly implement the cultivation of core literacy in every teaching link in the teaching process, and students can't get a comprehensive promotion of core literacy in experimental teaching, See Table 1.

Table 1. Designing Teaching Objectives.

Experiment Topic	Core Literacy Objective	Teaching Activity
Exploring the Relationship Between Acceleration, Force, and Mass	Master experimental operation skills; cultivate scientific thinking and inquiry; develop scientific attitude	Introduction: Pose questions, stimulate inquiry; Operation: Focus on experimental skills; Data Analysis: Encourage rigorous scientific thinking
Electromagnetic Induction	Understand the real-world applications of electromagnetic principles; enhance inquiry ability	Experiment: Build a simple generator; Connect with real-life technology like wind and hydropower generation
Braking Distance of Automobiles	Apply knowledge of kinematics and mechanics to solve real-world problems	Design and measure: Explore the relationship between speed, friction, and braking distance

3.2. Teaching Content

The content of the experiment is not closely related to real life, and it lacks interest and practicality. At present, many experiments in senior high school physics experiment teaching are based on classic experiments in textbooks. Although these experiments can help students master basic physics knowledge and experimental skills, they are often

divorced from real life. When students do experiments, it is difficult to understand the practical value of these experiments, thus reducing their interest and enthusiasm for experiments.

For example, in the "circuit connection" experiment, the content of the experiment is simply to let students connect the circuit according to the circuit diagram and measure the voltage and current, without guiding students to think about the application of the circuit in real life such as household electricity and electronic equipment. In addition, the design of some experimental contents is too old, lacking a sense of the times and unable to attract students' attention.

The selection of experimental content has limitations on the cultivation of students' scientific thinking and inquiry ability. Most of the existing experiments are confirmatory experiments, that is, students follow the experimental steps and methods given by teachers, and finally verify the existing conclusions in the textbook. Although this experimental mode can help students consolidate their knowledge, it is not conducive to cultivating students' scientific thinking and inquiry ability.

Because in the confirmatory experiment, students don't need to ask questions, design the experimental scheme and think deeply, they just need to follow the established steps. This makes students lack initiative and creativity in the experiment process, and can't really experience the fun and process of scientific inquiry, See Table 2.

Table 2. Innovative Teaching Content.

Experiment Topic	Innovation Focus	Relevance to Students' Lives
Simple Generator (Electromagnetic Induction)	Hands-on project; use of real-life principles	Students learn how electricity is generated and applied in wind power, hydropower
Braking Distance of Automobiles	Application of multiple physics concepts	Connects directly with real-world technology and everyday safety
Exploring the Period of a Simple Pendulum	Inquiry-driven experiment design	Students hypothesize and verify the factors influencing the period of a pendulum

3.3. Teaching Methods

The traditional experimental teaching method is mainly based on teacher's demonstration, and students' participation is not high. In many high school physics experiment classes, teachers are often the leaders of experiments. They give experimental demonstrations on the platform while students watch them from below. Although this teaching method can let students see the experimental phenomenon intuitively, students only passively accept knowledge and lack the opportunity of personal experience and practical operation.

For example, in the "refraction of light" experiment, teachers demonstrate with laser pens and glass bricks on the podium, and students can only watch the experimental phenomenon from a distance, but can't operate it by themselves and feel the refraction law of light. This makes students' understanding of the experiment not deep enough, and can't improve their practical ability and practical operation ability.

Teaching methods are insufficient in guiding students to explore independently and cooperate with each other. The existing teaching methods often pay too much attention to teachers' teaching and students' passive acceptance, while ignoring the cultivation of students' subjective status and autonomous learning ability. In experimental teaching, few teachers adopt inquiry-based and cooperative teaching methods to guide students to ask

questions independently, design experimental schemes, conduct experimental inquiry and cooperative exchanges.

This makes students lack the ability of independent thinking and teamwork in the experiment process, and can't cultivate their scientific inquiry spirit and innovation ability, See Table 3.

Table 3. Teaching Methods and Means.

Teaching Method	Key Features	Benefits for Students
Inquiry Teaching	Students independently ask questions, design experiments	Encourages critical thinking and active participation
Project-based Teaching	Real-life project connections	Bridges theory with practice, fostering comprehensive application of knowledge
Cooperative Teaching	Group-based experiments and discussions	Cultivates teamwork, communication, and problem-solving skills
Modern Educational Technology	Use of multimedia, virtual experiments	Enhances engagement, provides flexibility, and facilitates complex experiments

3.4. Teaching Evaluation

The evaluation method is single, which pays too much attention to the experimental results and ignores the performance of students in the experimental process. At present, the evaluation of physics experiment teaching in senior high schools is mainly based on experimental reports and test scores. This evaluation method only pays attention to students' experimental results and ignores students' performance in the experimental process, such as experimental design ability, operational skills, teamwork spirit and scientific attitude.

For example, when evaluating students' "Newton's Second Law" experiments, teachers often only look at whether the experimental conclusions drawn by students are correct, but don't pay attention to whether students can correctly use experimental instruments, independently design experimental schemes, and effectively cooperate with team members.

The evaluation index does not fully consider all the elements of physical core literacy. The existing evaluation indicators mainly focus on the assessment of students' knowledge and skills, but pay little attention to the evaluation of students' core literacy elements such as physical concept, scientific thinking, scientific inquiry and scientific attitude and responsibility. This makes the teaching evaluation unable to fully reflect the students' physical core literacy level, and also unable to provide targeted suggestions for teachers' teaching improvement. At present, there are many problems in the cultivation of core literacy in high school physics experiment teaching, which need teachers and educators to take effective measures to improve it, so as to improve the quality of high school physics experiment teaching and promote the overall improvement of students' core literacy in physics.

4. Innovative Strategies of Physics Experiment Teaching in Senior High School Based on the Cultivation of Physics Core Literacy

4.1. Optimize the Design of Teaching Objectives

Teaching objectives are the starting point and destination of teaching activities. For physics experiment teaching in senior high school, it is very important to set teaching

objectives according to the requirements of physics core literacy. The core quality of physics includes four aspects: physical concept, scientific thinking, scientific inquiry, scientific attitude and responsibility. Teachers should refine these requirements into clear, concrete and operable teaching objectives.

For example, in the experiment of "exploring the relationship between acceleration and force and quality", students should not only master the experimental operation skills and draw experimental conclusions, but also incorporate the scientific thinking of cultivating students' control variable method, gaining regular scientific inquiry ability through experimental inquiry, and respecting the scientific attitude and responsibility of experimental data into the teaching objectives. In order to make all elements of core literacy run through the whole process of experimental teaching, we should design around the cultivation of core literacy from the introduction, operation, data analysis and conclusion summary of the experiment. In the experiment introduction, students can be guided to ask questions based on existing physical concepts and stimulate their desire for scientific inquiry; In the process of operation, train students' practical ability and scientific thinking; Cultivate students' rigorous scientific attitude in the stage of data analysis; Conclusion the students' understanding of physical concepts should be strengthened when summing up.

4.2. Selection and Organization of Innovative Teaching Content

In order to improve students' interest and enthusiasm in physics experiments, the teaching content should be combined with the reality of life and the frontier of science and technology. There is physics everywhere in life. Choosing interesting and practical experimental content can make students feel the charm and value of physics. For example, when studying electromagnetic induction, we can design an experiment to make a simple generator by using the principle of electromagnetic induction, so that students can understand how electricity is generated and how this principle is widely used in life, such as wind power generation and hydropower generation.

Designing comprehensive and inquiry experimental projects is also the key to cultivate students' comprehensive application ability and inquiry spirit. Comprehensive experiments can integrate multiple knowledge points and require students to use what they have learned to solve complex problems. For example, designing an experiment about "exploring the factors affecting the braking distance of automobiles" involves many physical knowledge such as kinematics and mechanics, and students need to comprehensively use these knowledge for experimental design, data measurement and analysis. Inquiry experiment emphasizes students' independent inquiry, which enables students to find and solve problems in the process of inquiry and cultivate their scientific inquiry ability.

4.3. Improve Teaching Methods and Means

Traditional teaching methods mainly focus on teachers' lectures and demonstrations, and students' participation is not high. In order to improve students' participation and initiative, teaching methods such as inquiry, project and cooperation should be advocated. Inquiry teaching allows students to ask questions independently, design experimental schemes and conduct experimental inquiry, so as to give full play to students' main role. For example, in the experiment of exploring the factors affecting the period of a simple pendulum, students can guess the influencing factors independently and then design experiments to verify them.

Project-based teaching combines experimental teaching with practical projects, so that students can learn and apply physics knowledge in the process of completing projects. For example, if students are asked to design and make a simple physical model, such as a bridge model, they need to consider the knowledge of structural mechanics and improve their comprehensive application ability. Cooperative teaching emphasizes cooperation

and communication between students and cultivates students' teamwork spirit. Students are divided into groups to carry out the experiment, discuss the experimental scheme and solve the problems encountered in the experiment.

Using modern educational technology, such as multimedia and virtual experiment, can enrich the forms and means of experimental teaching. Multimedia can show the experimental principle and process through pictures, videos and other forms to help students better understand. Virtual experiment allows students to do experiments in a virtual environment, which is not limited by time and space, and can also carry out some experiments that are difficult to realize in reality, such as the movement experiment of microscopic particles.

4.4. Improve the Teaching Evaluation System

The existing teaching evaluation methods often pay too much attention to the experimental results and ignore the students' experimental process. In order to comprehensively evaluate students' physical core literacy, we should establish diversified evaluation methods and comprehensively consider students' experimental process and results. Teachers' evaluation, students' self-evaluation and mutual evaluation can be combined. Teachers' evaluation can be comprehensively evaluated from the aspects of experimental operation skills, scientific thinking ability and scientific inquiry ability. Students' self-evaluation can make students reflect on their performance and gains in the experimental process; Mutual evaluation can promote communication and learning between students.

Make a comprehensive evaluation index, covering all aspects of physics core literacy. The evaluation index should not only pay attention to students' knowledge, but also pay attention to the development of students' physical concepts, scientific thinking, scientific inquiry and scientific attitude and responsibility. For example, when evaluating students' experimental reports, we should not only look at the accuracy of experimental data and the correctness of conclusions, but also look at whether students reflect scientific thinking and inquiry spirit in the experimental process and whether they have a rigorous scientific attitude.

4.5. Strengthen the Improvement of Teachers' Professional Quality

Teachers are the organizers and guides of teaching activities, and their professional quality directly affects the teaching quality. Organize teachers to participate in the training and learning activities related to the core literacy of physics, so that teachers can deeply understand the connotation and requirements of the core literacy of physics and master the teaching methods and strategies based on the cultivation of core literacy. Training can invite experts to give lectures and share the latest educational ideas and teaching experience.

Encourage teachers to carry out teaching research and practical exploration, and constantly improve the teaching level. Teachers can combine their own teaching practice, carry out research on the innovation of physics experiment teaching, and explore teaching modes and methods suitable for students. Schools can set up teaching research topics, provide research support and platforms for teachers, promote exchanges and cooperation among teachers, jointly improve the quality of physics experiment teaching, and better cultivate students' physical core literacy.

5. Conclusion

Physics experiment teaching in senior high school is very important for the cultivation of students' physical core literacy. By analyzing the connotation of physics core literacy, the characteristics of physics experiment teaching in senior high school and their relationship, and discussing the problems existing in the cultivation of core literacy in current experiment teaching, this paper puts forward a series of innovative strategies.

Optimizing the design of teaching objectives can make core literacy run through the whole teaching process and ensure the correctness of teaching direction; Innovating the selection and organization of teaching content, combining with the reality of life and the frontier of science and technology, can stimulate students' interest and cultivate comprehensive ability; Improving teaching methods and means and using modern educational technology can improve students' participation and initiative; Perfecting the teaching evaluation system and establishing diversified evaluation methods and comprehensive indicators can comprehensively consider the development of students' literacy; Strengthening the improvement of teachers' professional quality provides a strong guarantee for teaching quality.

In practical teaching, we should comprehensively apply these strategies, constantly improve the physics experiment teaching, and earnestly implement the cultivation of physics core literacy, so as to lay a solid foundation for students' all-round development and future scientific research.

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