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Research on Teaching Strategy of Scientific Thinking Method in Middle School Physics from the perspective of Shandong Normal University Practitioner Skills Competition

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Abstract

The competition is one of the important platforms to promote and cultivate students' teaching skills and an important initiative to implement the training of application-oriented talents. In the long-term organization of students competition, we found that the contestants often failed to adequately demonstrate scientific thinking methods in physics teaching. When it comes to teaching plans, many participants have a tendency to emphasize knowledge content but not thinking methods, conclusions but not applications, teaching problem solving but not feedback on knowledge points. Students often lack an introduction to the scientific thinking process behind knowledge and do not tap enough into the creative thinking that goes into knowledge formation. To address this problem, this thesis discusses strategies to cultivate and promote students' attention to the teaching of scientific thinking methods and advocates a teaching philosophy that is led by the development of scientific thinking methods.

Keywords

Physics major; Scientific thinking method; Middle school physics teaching; Teaching competition.

1. Introduction

Guiding undergraduate colleges and universities into application-oriented transformation is an important part of the side structural reform of the supply of talents in education. The Outline of the Thirteenth Five-Year Plan for National Economic and Social Development clearly proposes to promote the transformation of qualified regular universities into application-oriented universities. In order to implement the decision of central authorities, promote the transformation and characteristic development of colleges and universities, improve the quality of application-oriented talents training, and enhance the ability to serve the economic and social development, Shandong Province has also formulated an implementation plan for the construction of high-level applied universities. For teacher training colleagues and universities, an important reform of application-oriented talents training is to pay attention to students' teaching practice and teaching skills. Shandong Normal University Practitioner Skills Competition is one of the main competition activities to pursue this goal. It is the highest level of student teaching skills competition sponsored by Shandong Provincial Department of Education, which has been held eight times so far. Every year, nearly 800 players from nearly 30 colleges and universities in the province are selected through various levels of competition. The contestants show their teaching skills, teaching ideas and teaching design in many aspects, such as speaking, giving lectures, oral examination and pen writing. To a certain extent, it reflects the application-oriented reform of cultivating physics talents in teacher training colleges universities of our province. As the organizer and instructor of physics students in our

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unit, we have organized and trained students to participate in this competition for many years, accumulated a lot of experience, and also found some problems to be solved.

In the core section of the competition, namely the simulation class, the judges mainly evaluate the contestants from six aspects: teaching manner and expression, teaching content, classroom atmosphere, teaching methods and means, teaching effect and personal characteristics. After the guidance and repeated training of the instructor, the contestants usually do well in all aspects. However, there has been a lack of one thing, that is, the display of scientific thinking method in physics teaching. In the scoring standard, the "scientific and accurate content explanation" in the teaching content and the "creative teaching process and distinctive characteristics" in the personal characteristics are all related to the teaching requirements of scientific thinking. However, in the teaching of most participants, there is still a tendency that they emphasize knowledge content but not teaching thinking methods, conclusions but not applications, problem solving methods but not feedback on knowledge points. [1]. The contestants often lack the introduction to the scientific thinking process behind the knowledge and fail to dig deep enough into the creative thinking that goes into the formation of knowledge.

Scientific thinking method is the soul of the development of physics, it is the cultivation of students' core competence from the perspective of cognitive mode and cognitive process. It is an advanced psychological activity that directly affects physics learning and solving physics problems. [2, 3] The 2017 edition of High School Physics Curriculum Standard upgrades the "three-dimensional curriculum goal" to "core competence of physics", emphasizing the formation of students' key ability and essential character after physics learning. But in the current middle school physics teaching, the teaching idea of cultivating scientific thinking has not been widely adopted. For example, in teaching, the introduction to new concepts and new laws and reasoning are mostly completed by teachers, giving students less time to explore and scientific debate. This project emphasizes that the cultivation of scientific thinking methods should be integrated into all aspects of teaching to cultivate students' core competence and grasp the essence of physics.

Inspired by the teaching weakness of physics majors in the Normal University Practitioner Skills Competition of teacher training colleges and universities, this thesis advocates a teaching philosophy that focuses on the cultivation of scientific thinking methods and exploring strategies to promote the importance of teaching scientific thinking methods to physics students.

2. Strategies and Examples of Scientific Thinking Method Teaching

2.1. Teaching Strategy of Scientific Thinking Method Training

Physics is an experiment-based science with a rigorous theoretical system, a quantitative science, and a science with a methodological nature. These characteristics make physics a very widely used basic science. As a physics major, students must have an in-depth understanding of these characteristics of physics, a clear understanding of the laws of development of physics, and a grasp of the cognitive characteristics of physics.

We propose to develop students' scientific thinking from all aspects of teaching according to their cognitive patterns, the developmental laws of physics, and the psychological characteristics of secondary school students (see Figure 1). The initial part of teaching provides perceptual materials and poses questions that lay the necessary foundation for deep cognitive processing. The perceptual materials should be magical, contemporary, and creative to attract students' attention and lead them to think. Let students discuss solutions to problems or give hypotheses and conjectures.

Secondly, we should pay attention to the model construction and go deep into the essence of physics. Physical modeling is an important scientific thinking, and it has gradually become a hot

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spot in the research of basic physics education. Model construction emphasizes on extracting the elements or parameters that can describe the phenomenon from the complex phenomenon, finding out the correct relationship between them, and constructing a model that can describe and explain the phenomenon.

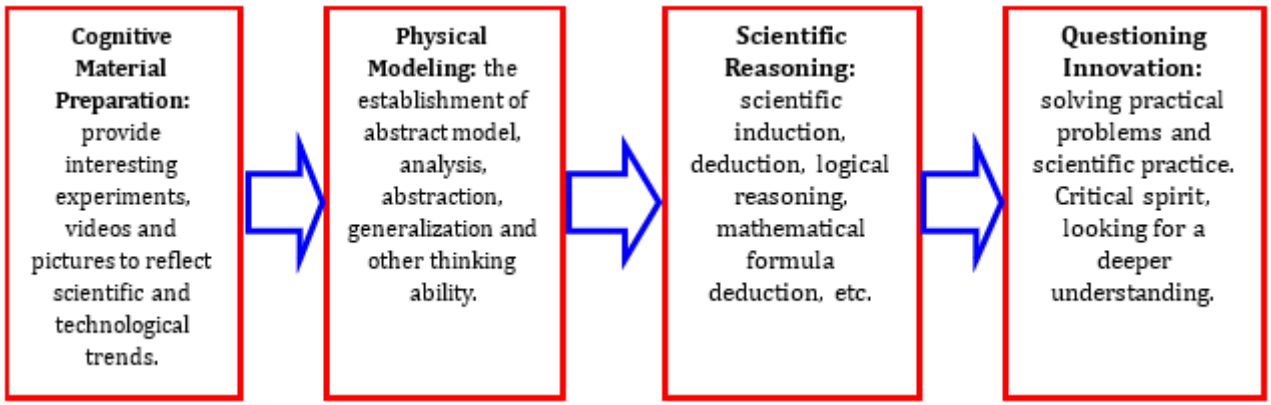

Figure 1. Cultivation of Scientific Thinking in Teaching Process

Thirdly, we should implement scientific reasoning and develop deep thinking. Scientific reasoning is not only an advanced form of scientific thinking, but also a key ability for students to solve physics problems. Let students understand the common scientific thinking methods and their applications, such as analysis and synthesis method, induction and deduction method, analogy method, transformation method, idealization method, etc. [4, 5] We ought to emphasize the logical reasoning process and mathematical formula derivation in the formation of physical laws.

Lastly, we should question innovation. Let students learn to use physical laws to solve practical problems and attach importance to scientific practice. In the process of seeking knowledge, we ought to maintain the spirit of scientific criticism and seek a deeper understanding of knowledge.

In specific teaching, different teaching activities can be used to achieve the above goals. For example, in the teaching design, experimental induction and theoretical induction are used to implement scientific reasoning. By encouraging questioning and debate, we can cultivate the ability of innovative thinking. Not only should we guide students to use the knowledge and experience they have mastered to produce some novel and unique solutions to problems, so as to effectively solve practical problems, we should also encourage students to question the teaches' proposal boldly and cultivate their scientific critical spirit consciously. The following context only takes the method of idealization and analogical thinking as examples to discuss the practice of scientific thinking method teaching.

2.2. Practical Examples of Scientific Thinking Method Teaching

2.2.1. Method of Idealization

The method of idealization is characterized by grasping the main contradiction of things, ignoring the secondary contradiction, and conducting a deeper inquiry process into the essence of the actual process of the objective object. That is, ignoring or discarding the secondary factors in the prototype, focusing on the dominant factors of the prototype, highlighting the main contradiction. [6, 7] The application of ideal model in physics teaching has three main forms: ideal model, ideal process and ideal experiment. In this thesis, the ideal model is taken as the only example. Method of physical model is a powerful tool for students to solve practical problems. Constructing correct physical models enables students to understand the essence of

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physical phenomena in greater detail and depth, which helps students solve physical problems and develop abstract thinking skills. There are many physical problems, especially some much more complex problems. Because the movement and change process of the research object is more hidden and complex, teaching practice has proved that if we choose a certain physical model to study, we can establish the relationship between the known and the unknown, and make the complex physical problems easier. The process of solving these physical problems, in essence, is the process of reducing specific physical problems to ideal models. Understanding and mastering the basic model in middle school physics is the precondition of using ideal model method to analyze physics problems. From the previous teaching skills competition, physics students often have a fair understanding of the model itself, but when guiding students to solve practical problems, they often do not emphasize that the ideal model is a scientific thinking method.

We can take the simplest particle model in junior high school physics as an example to illustrate this problem. For example, some students choose the following examples to explain the speed problem. "The railway bridge of the Yangtze River Bridge has a total length of 6,800 meters. A train runs on the bridge at a constant speed of 20 m/s. The time taken for the train to pass the bridge is 5 minutes. Please find out: (1) the length of the train, (2) the time it takes for the train to travel all over the bridge." For junior school students who are just beginning to learn physics, this is a problem that is easy for students to make mistakes and difficult for them to understand. Most students feel it impossible to start, since there is no clear physical image to compare. When teaching this kind of problems, contestants can often help students understand the problem with the help of images. In addition, some of them have summed up a lot of "strategies" for such problems. However, the most fundamental physical thoughts and thinking methods are often not emphasized. After careful analysis, the fundamental reason why students feel difficult to understand the matter has something to do with the understanding of the particle model. Obviously, a train with a certain length (or shape) is not a particle. This makes it difficult for students to understand the starting point of distance and timing. However, we can take a geometric point on the train as the research object. For example, one dot on the locomotive represents the whole train. The problem can be solved by studying the distance and the corresponding time and with the help of the speed formula.

The teacher should guide the students to think in the process of solving the problem, and emphasize on how to apply the particle model and let the students understand the idealized method is the key point of explaining the problem. The competitors often focus on the application of questions and formulas, a result of losing the education on the essence of physics. In the teaching process, we should consciously guide students to form a profound understanding of the particle model, so that they know that this is a scientific thinking method. Let students know that objects in real life are not particles, some can be simplified as particles, some can not be regarded as particles (such as considering rotation). In this question, let the students think about whether the train is a particle, what is the difference between it and the ball in the usual topic. In this way we can deepen students' understanding of the ideal model.

Paying attention to practical application is an important aspect of junior high school physics teaching reform. More and more topics will be closer to the reality of life, no longer the simple proposition based on the model itself, such as a spring oscillator, rigid body, particle, lever and so on. For practical problems, the first thing to do is to find the corresponding physical model, and then use the law to solve the problem. The cultivation of scientific thinking method and scientific competence is an important aspect of cultivating innovative talents.

2.2.2. Analogical Thinking

Analogical associative thinking is a creative thinking method. According to the fact that two objects have some similar attributes, it deduces that they may have the same attributes in other

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aspects, and thus conceives the thinking method of spiritual object with certain basis. [8] The application of analogical thinking is conducive to the breakthrough of teaching difficulties by transforming abstraction into images in teaching. [9] Due to the limitations of middle school students' knowledge foundation and thinking level, students often need to use analogy method to learn new physical concepts or establish more abstract mathematical relations about physical quantities on the basis of mastered knowledge, methods and familiar things. For example, after learning mechanical vibration and mechanical wave, when learning about light, we can make an analogy, and preliminarily get that light also has volatility, interference and diffraction phenomenon, Doppler Effect (red shift) and so on. There are also bucket volume and capacitance, gravitational potential energy and electric potential energy, mass inertia and capacitor capacitance. Maxwell once wrote about analogy: "In order to get physical ideas without using physical theory, we should be familiar with the existence of physical analogy. The so-called physical analogy refers to the partial similarity between one scientific law and another, which enables the two sciences to explain each other. Maxwell's equations of electromagnetic field theory were established by imitating the equations of fluid mechanics. The knowledge of the history of physics tells us that the application of analogy almost runs through the development of physics.

Let us take Coulomb's Law as an example to discuss the problems often encountered by competitors. The discovery of Coulomb's law is undoubtedly a model of successful application of analogical thinking in scientific research. yIf it is not for the discovery of the law of universal gravitation, we do not know when we will get the expression of the strict Coulomb's Law only by the accumulation of experimental data. In fact, the whole development of electrostatics is based on the achievements of the law of gravitation. The development of gravitation theory provides a theoretical weapon for electrostatics and magnetostatics, which makes electromagnetics avoid many detours and directly form a strict quantitative law. [10]

Unfortunately, most students do not introduce this analogical thinking method enough in the teaching of Coulomb's Law. Some do not mention the analogy of the law of universal gravitation. Although some of them mentioned it, they just made a formal comparison and failed to realize that it was a real research method used in the discovery of Coulomb's Law. The history of physics shows that the British chemist Priestley proved through experiments in 1755 that the hollow charged body really has no force effect on the charge in it. The clever Priestley immediately connected Newton's law of gravitation from this fact. Newton had proved mathematically that if the inverse square law is valid, a uniform spherical shell composed of gravitating matter has no gravitation on its internal objects, and any force that does not satisfy the inverse square relation will not have such a result. So Priestley boldly put forward his own idea: the interaction between charges, like gravitation, also follows the law of inverse square. Although he did not give a strict proof at that time, this reasoning strongly promoted other explorers to verify it with experiments. Later, the French scientist Coulomb also noticed that there are many similarities between the electrostatic force between charges and the law of gravitation, so he boldly assumed that the law of electrostatic force is similar to the law of gravitation. The law of electrostatic force and the law of universal gravitation are obviously independent of each other. By comparing these two, people feel the desire to explore the hidden secrets of nature. Later, with the experimental efforts of a large number of scientists, Coulomb's Law was established in 1785. In teaching design, we should guide students to understand the important role of analogical thinking in the discovery of Coulomb's Law, and spill out the essence of physical science.

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3. Conclusion

Nowadays, taking the teaching concept of core competence of subject training as the mainstream has not been widely popularized. Although modeling teaching has attracted the attention of physical education, the essence is not well known and less attention is paid to the modeling process. In the process of scientific reasoning, the explanation of new concepts and new laws is mostly completed by teachers, which gives students limited time for thinking and scientific debate. The lack of students' creative abilities is a pain point of physics teaching today, and the development of scientific thinking is a shortcoming of secondary school physics teaching. This project proposes that physics teaching should be implemented in all aspects of teaching with the development of scientific thinking skills as the mainstream method. We should put scientific thinking through the whole process of students' cognition and cultivate the core competence of physics majors.

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