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# Research on Effective Strategies of Scientific Methods in Junior High School Physics Teaching Based on the Concept of Three-Dimensional Objectives

Qi Zhang[1], Minghui Shao[2,*], Xue Wang[3]

[1,2,3]*School of Physics and Technology, University of Jinan, Jinan, China*
*ss_shaomh@ujn.edu.cn*

**ABSTRACT**
As an important link between the Three-Dimensional Objectives, the scientific methods have important methodological significance for cultivating students' ability of scientific inquiry and improving students' scientific literacy. According to the requirements of the curriculum standard, combined with the current implementation of junior high school physics teaching, the Three-Dimensional Objectives are used as the theoretical basis, and scientific methods are infiltrated, so that the teaching content can correspond to the scientific methods, and further highlight the significant advantages of the scientific methods in achieving the Three-Dimensional Objectives. Finally, the scientific methods are discussed in several aspects, in order to promote the real implementation of the scientific method education.

***Keywords:*** *Three-Dimensional Objectives, scientific methods, junior high school physic*

## 1. INTRODUCTION

The Ministry of Education of our country promulgated the "Compulsory Education Physics Curriculum Standards (2011 Edition)" at the end of 2011. The new curriculum standards stipulate: The purpose of compulsory education course is to allow students to learn the basic knowledge and methods of physics necessary for life-long development and develop good thinking. Habits try to use scientific knowledge and scientific research methods when analyzing and solving problems, and have the consciousness of using research methods. The Compulsory Education Physics Curriculum Standards aims at improving students' scientific literacy, focusing on cultivating students' scientific inquiry ability, and laying a solid foundation for promoting students' lifelong learning and all-round development [1]. Therefore, in this era of knowledge constantly updated, students learn to master the methods of knowledge, which greatly promotes the cultivation of students' innovative spirit and practical ability, as well as the improvement of students' competitiveness in the future world.

From the previous Double Bases Teaching to the later Three-Dimensional Objectives, it can be seen that our country's education objectives have gradually changed from "Knowledge-Oriented" to "Ability-Oriented". The curriculum standards also emphasized the need to strengthen students' ability to use scientific methods to explore problems. However, there are still many problems in the specific implementation. First, many front-line teachers have not implemented the requirements of the new curriculum standards in their teaching. And teachers have a vague understanding of the specific content, definition and form of the scientific methods, etc. Moreover, they cannot achieve accurate implementation of the teaching objectives. Second, the teaching process is formalized. Some teachers only briefly introduce the scientific methods in textbooks, and directly teach them to students in the form of conclusions. As a result, students do not experience the process of independent discovery and only memorize the content of the methods. The ability to use scientific methods to solve problems is weak. Third, the evaluation system for students' knowledge mastery ability is relatively simple. Most of them are based on examinations, which leads to the misunderstanding of teachers who regard "Test Points" as "Critical and Difficult Points" for teaching. So, they ignore the importance of scientific methods education. This kind of phenomenon makes students only

master knowledge, and their knowledge of the inquiry process is still shallow. As a result, they "know it but don't know why" in the study of physics.

With the advent of an innovative society, the concept of scientific methods education has gradually been advocated by countries all over the world. And many countries regard scientific methods as one of their curriculum objectives when formulating curriculum objectives. In the 1990s, the method goal of Japanese junior high school physics education goal is: find problems in things and phenomena related to matter and energy, learn to find laws and explain the methods of natural phenomena through the process of scientific investigation [2]. And many domestic scholars have conducted research and discussion on scientific methods. In 1995, the "National Physics Scientific Methods Education Symposium" was held in Xi'an for the first time. Since then, it has been successfully held many times under the organization and guidance of many physics' education experts such as Zhang Xiankui [3]. The conference has provided physics teachers with more accurate and effective scientific methods teaching suggestions. And it further implements the new curriculum standard concept and promote the development of physics curriculum to a deeper level. Li Fuchun, Li Chunmi, and Xing Hongjun put forward the explicit education of scientific method. They pointed out that the specific method of explicit scientific method is to clarify the name, reveal the form, explore the connotation, explain the conditions of use, and strengthen training [4]. The NPC&CPPCC held in 2019 clearly proposed to deepen the reform of education and teaching and comprehensively improve the quality of compulsory education. What is more, learning of scientific method has played a vital role in comprehensively improving the scientific literacy of students.

## 2. THEORETICAL BASIS

The scientific method is the method and means produced by people in the process of understanding objective things [5]. And people's understanding of it is still constantly enriched and deepened, which is a broad and developing concept. Scientific method can be divided into broad and narrow senses. In a broad sense, they refer to the methods, strategies and approaches that people adopt in understanding and transforming the world in line with general scientific principles, including research methods in nature, society, and science, etc. They are universal significance. In a narrow sense, it refers to the approach, thinking, or procedure followed in the process of researching natural scientific problems or learning. For example, raising questions, conjectures and hypotheses, making plans, and analyzing and demonstrating. As an important part of Three-Dimensional Objectives, scientific methods are formulated in the Compulsory Education Physics Curriculum Standards. The Three-Dimensional Objectives are the "Overall Objective of the Course", including knowledge and skills, process and methods, emotional attitudes and values. The new curriculum standard emphasizes the organic unity of Three-Dimensional Objectives. As the link and bridge for the effective connection of the three objectives, scientific methods understand its connotation and accurately implements it, and effectively penetrates into the teaching. It can better help students master the physics knowledge, improve the ability of scientific inquiry. At the same time, it plays an important role in establishing correct values and promoting the harmonious development of Three-Dimensional Objectives.

According to Professor Zhang Xiankui's classification method in "Physical Science Method Education", the scientific method is divided into two types: conventional methods and unconventional methods [6]. Conventional methods refer to research methods with certain rules and procedures. And conventional methods can be subdivided into classic methods and modern system science methods. Such as the classic observation method, experimental method, logical reasoning method, mathematical method, and modern information theory, system theory method, etc. Another type of unconventional methods refers to research methods without fixed rules and procedures. The production of these methods is accidental and is often mixed with sudden situations, such as mistakes and paradoxes, intuition and inspiration, physical aesthetics, opportunities, etc. These scientific methods are usually contained in the content of junior high school physics teaching in the following three forms. The first form: the establishment of physical concepts and laws exists in scientific methods. For example, when we establish the concepts of density, power and pressure, we will use the ratio definition method. It is a method to define concepts using the ratio of two or more physical quantities. For the application of this method, the key is to select two physical quantities of the same specification for comparison. The purpose of this is that students can reveal the physical meaning of the defined concept from the measurement formula and understand the true relationship between the learned concept and the related concept. The second form: scientific methods exist when there is correlation between different physical knowledge. For example, when exploring the size of the current and which factors related to the experiment, first use the analogy method to make reasonable guesses about the influencing factors. And then use the control variable method to explore the relationship between current, voltage, and resistance. Finally, the formula of Ohm's law is obtained through analysis, induction and mathematical methods. In an exploratory experiment, it embodies the application of analogy, control variable, induction and mathematical methods between physical quantities. The third form: there is a scientific method when applying knowledge to practical situations to solve problems, and

knowledge itself has methodological significance at this time. For example, when we know the mass and density of an object and need to identify the type of substance, we need to use the concept of density to calculate. Then, we compare with the density table in the textbook to get the type of substance. At this time，density has become a solution to the problem.

## 3. STRATEGIES TO INFILTRATE THE FACTORS OF SCIENTIFIC METHODS IN THREE-DIMENSIONAL OBJECTIVES

According to the specific requirements of the curriculum standards, through the analysis of the role of the scientific method in the Three-Dimensional Objectives and the physics textbook, I think that scientific methods should be rationally infiltrated in classroom teaching to promote more complete curriculum content. The specific strategies are as follows:

### *3.1 The scientific method as an intermediary to strengthen the connection of knowledge*

As a link between physical knowledge and phenomena, the scientific method can effectively provide thinking guidance for knowledge. And it also can link abstract knowledge with actual situations, create a visual form, and construct a framework in students' minds to integrate knowledge. Therefore, teachers should carefully study the content of the textbook and extract the corresponding scientific methods from it. And teachers should connect the actual life, apply the scientific methods, and create a life situation for teaching. For example, when studying the magnetic field, it is difficult to show the phenomenon of magnetic field. Then you can use the analogy method. In the experiment where the fan blows the cloth strips, the shape of the wind is invisible. Using the fan to blow the cloth strips proves the existence of wind, and guides students to draw the direction and magnitude of the wind based on the phenomenon. According to the analogy, wind can be compared to magnetic field. This method inspires students to consider how to study the strength and direction of the magnetic field, so that students can learn how to make the study of intangible matter concrete.

### *3.2 Taking the scientific method as the objective & turning passive into active inquiry*

Taking scientific method education as one of the teaching objectives will help students understand the process of scientific inquiry, strengthen the ability of active inquiry. At the same time, it can deepen students' understanding of the nature of scientific methods. And have a deeper meaning for students to use physics knowledge to solve practical problems flexibly. Therefore, teacher should design classrooms according to the students' cognitive style and the logic of scientific methods. And teacher should take method education as the center of teaching activities. The activities are designed with the physical knowledge taught as the bright line and the infiltrating scientific method as the dark line. This way can more stimulate students' curiosity, enable students to actively participate in classroom activities, and turn passive learning into active exploration. It is helpful for students to truly understand physics knowledge, experience the process of scientist's inquiry, and feel the true meaning of physical science.

### *3.3 Using mathematical method as a tool to promote the explicitation of logic problems*

In physics learning, logical reasoning oriented by scientific method is bound to be inseparable from the application of mathematics. Effective use of mathematical method can better promote the development of physics research. Therefore, teacher should reasonably use mathematical method and analyze the essence of mathematical method. And teacher should clarify the way that mathematical methods are displayed in physics and the connection with physical knowledge. Then teacher can use mathematical methods to explicitly present abstract logical problems. This can help students establish a clear understanding of physical quantity and summarize the laws of physics more effectively. For example, crystal and non-crystal are in the molten state. As shown in the Figure 1, that is, when one physical quantity changes with another physical quantity, Students' experimental records can use the two-dimensional coordinate system in mathematics to trace points in the time and temperature coordinate system. And they can draw the image of the melting state of crystal and non-crystal during temperature changes. The purpose is to help students intuitively grasp the characteristics of the two.

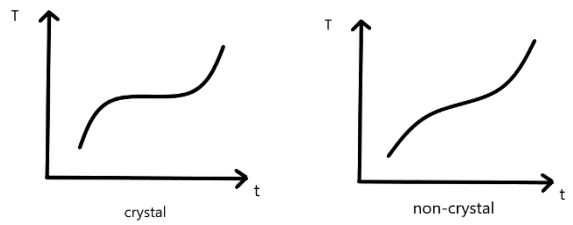


**Figure 1** A curve of the temperature of an object as it melts

### *3.4 Exploring the origin of physics and experiencing the scientific process*

When scientists establish physical concepts, most of them go through the process of scientific inquiry such as conjecture, questioning, overthrowing, and reconstruction. Therefore, scientific method as a medium

of scientific inquiry has important methodological significance. If students can understand the origin and evolution of physical concept, they can strengthen their understanding of scientific methods. Professor Wu Guosheng mentioned in the book "The History of Science": Understanding the history of science helps to understand the social role and humanistic significance of science [7]. Teachers should permeate the origin and development of the concept when explaining the concept and tell the research process of scientists. It can help students feel the way scientists think about problems. It is helpful for teachers to carry out the teaching activities with knowledge as the carrier and the purpose of mastering scientific methods. In addition, the use of scientific methods to conduct research can not only deepen the understanding of the laws of concepts, but also cultivate the scientific spirit of students to think independently and dare to question, change students' misunderstanding of scientific history, and establish correct values. For example, in the teaching of Newton's First Law, through the exploration of scientific methods such as observation method, experiment method, reasoning method, ideal experiment method and the generation of cognitive conflict, to make students understand physical concepts is to test them in questioning, guessing and experiments

## 4. CONCLUSION

The purpose of the Compulsory Education Physics Curriculum Standards is to improve students' scientific literacy. And it requires students to try to use scientific knowledge and scientific research methods when analyzing and solving problems, and to have the awareness of using scientific methods. Firstly, the author puts forward the problems of "what to teach" and "how to teach" existing in junior high school physics teachers. Secondly, this paper analyzes the classification and existing forms of scientific methods in junior high school physics textbooks. Finally, this paper puts forward the strategy of infiltrating scientific methods into Three-Dimensional Objectives. This article guided by the physics curriculum standards, emphasizes the importance of scientific methods to achieve the Three-Dimensional Objectives, and lists examples to explain, hoping to promote the teaching of scientific methods for educators.

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