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Original Paper

Teaching Design of High School Physics Concepts under the Unit Concept: Taking Description of Motion as an Example

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Abstract

The new high school physics curriculum standards put forward for the first time that "physical concepts are the sublimation of physical concepts and laws", from which it can be seen that the teaching of physical concepts is the foundation of high school physics teaching. This article will take Chapter 1 "Description of Motion" of the first compulsory course of high school physics published by the People's Education Edition as an example and conduct a preliminary exploration of the design of teaching objectives, preconcepts, teaching situations, classroom teaching and teaching evaluation based on the concept of large units.

Keywords

Physics Curriculum Standards Teaching of physical concepts The concept of large units

The core literacy of the physics subject first proposed in the "General Senior High School Physics Curriculum Standards (2017 Edition)" issued by the Ministry of Education of China is a concentrated manifestation of the educational value of the subject. It is the correct values, essential qualities and key abilities that students gradually form through subject learning. (Ministry of Education of the People's Republic of China General Senior High School Physics Curriculum Standards (2017 Edition) Among them, the concept of physics, as the foundation of core literacy, is of self-evident importance. And physical concepts are the refinement and sublimation of physical concepts and laws in the mind. Therefore, the teaching of physical concepts has become a fundamental link in cultivating students' core literacy in the field of physics. The 2022 Compulsory Education Curriculum Plan clearly states in the "Curriculum Implementation" section that "we should explore large-unit teaching, promote students' ability to learn by analogy and integrate knowledge, strengthen the intrinsic connections among knowledge, and facilitate the structuring of knowledge." (Ministry of Education of the People's

Republic of China Compulsory Education Curriculum Plan (2022 Edition)) From this, it can be seen that "large-unit teaching" is to achieve in-depth teaching by structuring knowledge and strengthening the intrinsic connections among knowledge, thereby promoting students' ability to apply what they have learned to new situations and integrate knowledge. (Dong, 2024) Through large units, in-depth teaching is achieved to develop students' core competencies and lay a foundation for their lifelong development. This article will design the teaching of high school physics concepts under the concept of large-unit teaching, taking Chapter One "Description of Motion" of the first compulsory course of high school physics published by the People's Education Edition as an example, and reflect on the possible problems.

1. Problems Existing in the Teaching of High School Physics Concepts

1.1 Excessive Emphasis on Concept Indoctrination

In the current teaching, teachers often do not attach enough importance to physical concepts. Some teachers equate physical concepts with the definitions of physical quantities, directly informing students of the physical definitions in the teaching of physical concepts and repeatedly nitpicky about the words in them. This completely suppresses students' independent exploration ability, makes their understanding of concepts superficial, and gradually causes them to lose interest in learning physics. For example, in the section "Particle Reference Frame", teachers often simply tell students what the concept of a particle is and emphasize under what circumstances an object can be regarded as a particle. In this way, students' understanding of a particle merely remains at the level of textual description. They have not gone through the process of constructing a particle model and will not truly understand the concept of a particle.

1.2 The Application of Concepts Is overly Mechanized

The teaching of any subject is aimed at applying what has been learned. For physics, only by truly applying the physical knowledge learned can one discover the misunderstandings in the understanding of concepts. At present, a major problem existing in students' understanding of concepts is that the application of concepts is overly mechanical. For instance, when learning the section "Law of Conservation of Mechanical Energy", some students believe that if air resistance is not taken into account, during the process of a small ball falling from the highest point to the lowest point, only gravity and elastic force do work. Therefore, the mechanical energy of the small ball is conserved, as shown in Figure 1. This result is caused by the mechanization of students' application of concepts.

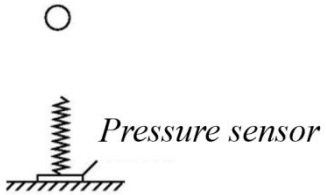

Figure 1. Analyzes the Mechanical Energy Changes of the Small Ball and the System

1.3 Blindly Memorizing Physical Concepts

Physical concepts do not exist independently; there are interconnections among concepts. However, most students' understanding of physical concepts often remains at the simple memory level, believing that "as long as physical concepts can be remembered, it is fine." Students who hold such an idea usually do not try to understand physical concepts better, which in turn leads to more difficult physics learning. For instance, students can all remember that the concept of velocity is "the ratio of displacement to the time it takes for that displacement to occur", and they can also know that displacement is a vector. However, some students often disconnect the two when applying the concepts of displacement and velocity to solve problems, ignoring the characteristic that velocity is also a vector. This leads to a relatively poor overall effect of concept learning.

2. Overview of Large Unit Teaching

The idea of large-unit teaching originated from the "insufficiency" of class hours at the beginning of teaching reform. In 1931, Morrison of the United States published the book "Teaching Practice in Middle Schools" based on his practice at the University of Chicago High School, and first proposed the Morrison Plan, namely the Morrison Large Unit Teaching Method. Usually, each month is regarded as a large unit and each one or two weeks as a small unit. It places more emphasis on group teaching. Teachers select unit themes for children based on their understanding of their abilities and interests, and prepare learning content and activities in advance. These learning contents and activities are not only related to the units, but also cover various fields. From today's perspective, for high school physics, large-unit teaching can be interpreted as: integrating interrelated content into a complete and larger teaching unit. This integration can be carried out through interesting physical phenomena in life; Or perhaps, based on their previous teaching experience, teachers break the sequence of textbook compilation in teaching content and rearrange and recombine the knowledge to achieve better teaching results. A complete teaching should include three stages: before class, during class and after class. Therefore, large-unit teaching cannot be limited to only one stage of classroom teaching. Before class, determine the teaching content and set the teaching objectives based on the curriculum standards and teaching materials. Effective teaching is carried out in class according to the teaching objectives. Evaluate students' learning outcomes in a timely manner after class, obtain feedback, and adjust future teaching goals based on this. From this, we can see that a complete large-unit teaching should include four elements: content, objective, implementation and evaluation. The four elements influence each other and progress layer by layer. As shown in Figure 2.

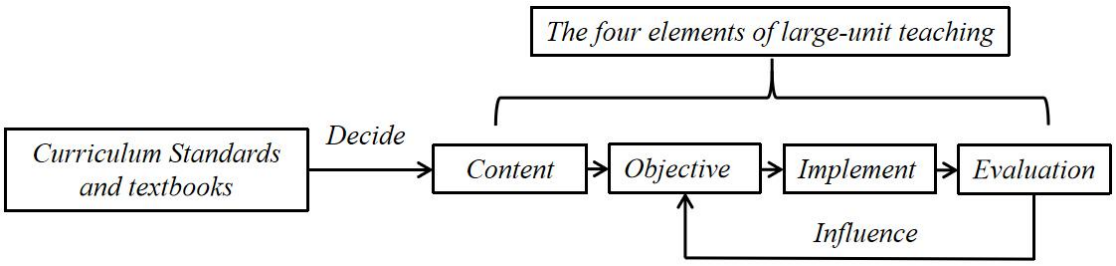

Figure 2. Shows the Four Elements of the Major Unit Teaching and the Relationships among Them

3. Advantages of the Large Unit Concept in the Teaching of Physics Concepts

Compared with traditional teaching, the complete large-unit teaching has greatly optimized the teaching process. Not only has the teaching efficiency been improved, but it can also better cultivate students' core literacy. The teaching of physical concepts that incorporates the idea of large units can integrate knowledge that is not originally part of the same class but is interrelated. While increasing the connection between knowledge, it can also enable students to better learn the methods of applying knowledge to solve problems, making them clear about "why they need to understand physical concepts" and avoiding the blindness of concept learning. It can also provide samples to students to enhance their modeling ability and develop core qualities such as the spirit of inquiry.

Take "Description of Motion" as an example. This chapter is divided into four sections. After students have learned the concept of "point mass" in the first section, they do not know "what point mass is used for". If the concept of "point mass" is combined with the knowledge of "velocity" and "acceleration" in this chapter, students will form a clear knowledge system in their minds and have a clearer understanding of the concept of point mass. Meanwhile, combining the above concepts in real scenarios can significantly enhance students' abilities in model construction and solving practical problems. From this, it can be seen that the large unit is also the basic unit for implementing core literacy and achieving scientific education. With the same teaching content, through large-unit teaching, not only has the teaching efficiency been improved, but also the core literacy of students has been cultivated, truly achieving the effect of "one plus one is greater than two".

4. Conceptual Teaching Design of High School Physics under the Large Unit Concept

4.1 Adjust the Way Teaching Objectives Are Achieved

Unlike the traditional teaching based on class hours, the teaching objectives of the large-unit concept teaching should not only revolve around the core literacy of physics but also encompass the entire unit. The teaching objectives of this chapter are designed in the following four dimensions, as shown in Table 1.

Table 1. Teaching Objective Design of "Description of Motion

Physical concept	(1) Master physical concepts such as particle, velocity and acceleration; (2) Understand the characteristics of physical models in physics research and appreciate their role in exploring natural laws.
Scientific thinking	(1) Experience the modeling process, understand the way of thinking in modeling, and recognize the role of physical models; (2) Connect with examples related to speed to understand the applications of physics in daily life and production
Scientific inquiry	(1) Students do not have a clear impression or in-depth thinking in their life experiences. Through group cooperation and exploration, they can distinguish whether the meaning of "fast" is high speed or high acceleration. (2) Understand the meaning of the direction of acceleration, be able to distinguish between velocity, change in velocity, and the direction of acceleration, know the conditions for acceleration and deceleration, and appreciate the significance of the rate of change in describing the process of change.
Scientific attitude and responsibility	(1) Through historical facts, initially understand the background of the emergence of modern experimental science and recognize the promoting role of experiments in the development of physics; (2) By explaining the development history of China's railways, cultivate students' sense of responsibility and mission.

The realization of the teaching objectives in the above table requires new teaching methods to be achieved. This article has also made a preliminary design for this, as shown in Figure 3.

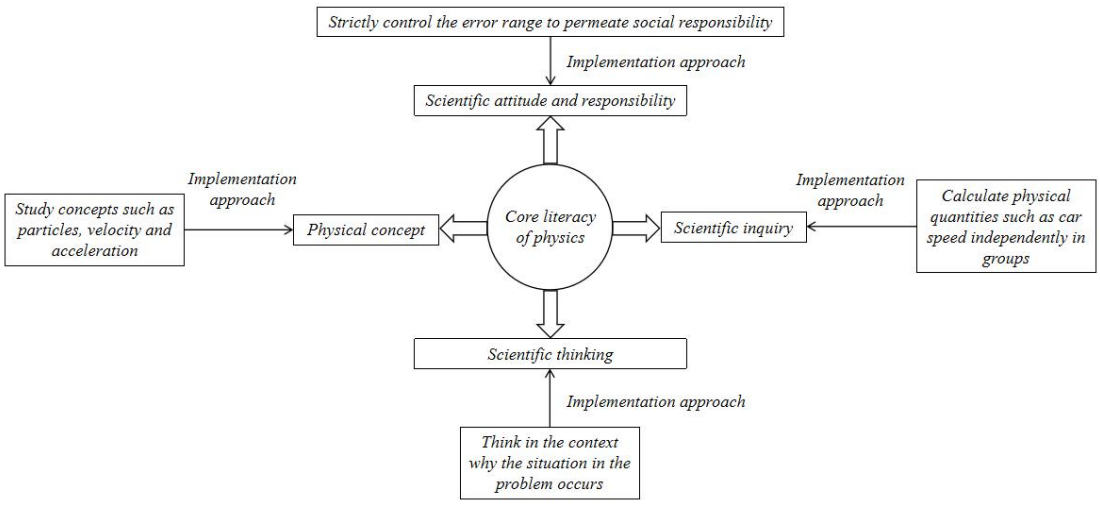

Figure 3. Ways to Achieve the Core Literacy Goals

4.2 Accurately Grasp Students' Preconceived Notions

Students' preconcepts will largely influence the learning of new concepts. Therefore, before the teaching begins, teachers should fully consider the preconcept factors, including: What kind of impact do preconcepts have on students? Are these impacts beneficial or misleading for the learning of new concepts? How to correct students' wrong viewpoints and how to use preconcepts to help students learn new concepts.

In junior high school, students have already learned the concepts of "speed" and "distance", but these concepts taught in junior high school are not rigorous and are quite different from those in senior high school. However, due to preconceived notions, students may not be able to change their minds in a short period of time. However, "distance" and "displacement" have similarities. Teachers can use the comparison of the concepts of distance and displacement to help students understand "displacement". As shown in Figure 4.

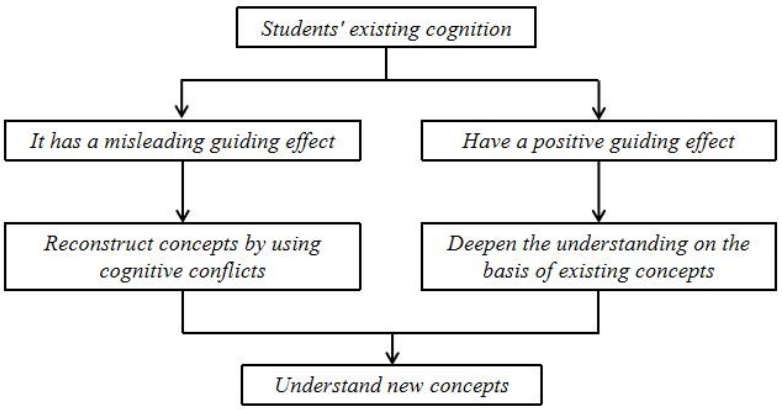

Figure 4. Uses Pre-concepts to Assist in the Understanding of New Concepts and New Understandings

Take the chapter "Description of Motion" as an example. In this chapter, middle school students have already learned the concept of "speed", but in junior high school, it is called "velocity". In senior high school, the concept of velocity is "the ratio of displacement to the time taken for that displacement to occur". This situation is very likely to cause cognitive conflicts among students. Teachers can take advantage of this cognitive conflict to help students reconstruct concepts, enabling them to have a clearer understanding of the concepts of "speed" and "rate". Meanwhile, students have already learned the concept of distance. In high school, a new concept of "displacement" was introduced. These two concepts have some similarities. By comparing the differences between the two concepts, teachers can help students clearly understand the concept and characteristics of "displacement". In this way, students will have a clear understanding of displacement.

4.3 Integrate the Concepts of Physics Units into the Teaching Context

The teaching situation should be established based on the real phenomena that are easily seen in life, and at the same time, it should permeate the physical concepts to be learned in this unit. Students work in groups to analyze which phenomena related to physics have emerged in the context and which ones are related to the content of this unit. They should then make written statements about the above content and conduct qualitative analysis of the physical phenomena they have stated. For individual students with stronger abilities, targeted analysis can also be conducted.

Take the chapter "Description of Motion" as an example. Based on all the concepts presented in this unit, design a situation of "comparing the motion of two cars" for students to analyze and discuss, as shown in Table 2.

Table 2. Design of Teaching Scenarios

Teaching situation	On August 1, 2008, China's first independently built high-speed railway with a maximum speed of 350 kilometers per hour - the Beijing-Tianjin Intercity Railway - was put into operation. On September 28, 2009, Wenling Railway Station was officially put into operation, and Wenling thus entered the "high-speed rail era". Suppose two cars, A and B, depart from Wenling Middle School simultaneously at 8:00 a.m. and head for Wenling Railway Station. It took Car A 30 minutes to reach Wenling Railway Station and Car B 60 minutes. But strangely, both cars started from rest, first accelerated and then moved at A constant speed (during the acceleration phase, the

	speed of the two cars changed uniformly). During the acceleration phase, car B was always in front of car A, but in the end, car A arrived first. Given that the routes taken by Train A and Train B are the same, the distance from Wenling Middle School to Wenling Railway Station is 20 kilometers, with a straight-line distance of 14.4 kilometers.
	Design intent: In this context, particles, moments, time intervals, displacements, velocities and rates appear. Students can experience these concepts in real situations.

It can be clearly seen from Table 1 that this teaching situation includes several physical quantities such as "particle", "moment", "time interval", "displacement", "velocity" and "rate". Before officially starting learning, students can have a clear understanding of these concepts by perceiving in the context. This kind of understanding can not only lay a good foundation for the learning of concepts, but also enable students to understand the extension of physical concepts and clarify their applicable scope.

4.4 Classroom Teaching Is Designed Around Unit Concepts

When designing teaching links, teachers should distill the core concepts that can encompass the content of the unit and the class period, and conduct teaching design based on the teaching objectives. At the same time, in classroom teaching, the principle of "student-centeredness" must be adhered to, ensuring that students' core qualities such as scientific thinking and the spirit of inquiry can be fully developed, as shown in Table 3.

Table 3. Problem Settings

Think about the problem	(1) Which physical quantities appeared in the above process? (2) Which of the two cars, A or B, is faster in the above process? (3) When studying the speed of movement of A and B, is it necessary to take into account the size and shape of the car?
	Design intention: The first question enables students to clearly understand what concepts are to be learned in this unit and first establish a clear

	knowledge framework in their minds; The second question hopes that students can generate cognitive conflicts and distinguish the differences between the concept of speed in junior high school and that in senior high school. The third question enables students to clarify the definition of a particle and under what circumstances an object can be regarded as a particle.

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Table 4. Student Activities

Student Activities	Students should think and discuss the above issues in groups within a time limit of seven minutes. After seven minutes, they should submit the discussion results in writing and share and exchange them throughout the class.

During this process, students' sense of teamwork and cooperative spirit can be cultivated through methods such as group discussions and cooperative learning. Meanwhile, during the process of group discussions, different ideas among students collide, which is conducive to the development of core qualities such as creative thinking.

The purpose of learning knowledge is to apply it. Large-unit concept teaching is an important approach to transforming students' knowledge literacy into ability literacy. However, at present, school teaching mostly aims at "small concepts", leaving students with very limited space for exploration. Teachers expect students to quickly obtain only or limited correct answers, which makes learning an act of acquiring knowledge rather than a process of broadening thinking. The physics concept classroom teaching designed based on the large unit concept effectively connects the unit concepts together, leaving students a larger space for exploration and enhancing their ability to apply knowledge. At the same time, when teachers lead students to sort out and clarify the unit concepts, and establish a conceptual system about this chapter in their minds, it can help students better understand the unit concepts and achieve a thorough understanding, as shown in Figure 4.

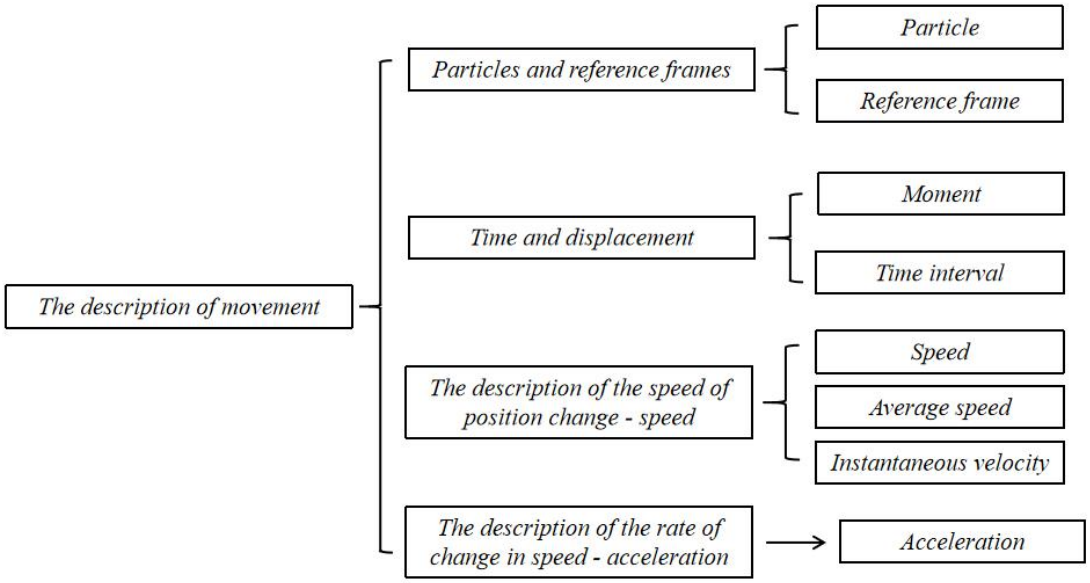

Figure 4. Main concepts of "Description of Motion"

4.5 Optimize the Evaluation Indicators

Whether a class has achieved the expected effect needs to be evaluated based on the corresponding evaluation mechanism. Then, according to the evaluation results, corresponding adjustments and optimizations should be made to the future teaching.

For the evaluation of the teaching effect of the concepts in this unit, a more complex problem situation can be designed and brand-new questions can be set for students to analyze. The evaluation of students' learning outcomes should not only focus on the completion of their homework, but also take into account their classroom teaching performance, the completion of after-class homework, after-class activities, and the results of comprehensive unit examinations. Finally, teachers fill out the learning effect evaluation form to systematize and visualize the evaluation of students. As shown in Table 5.

Table 5. Evaluation Form for Learning Effect Achievement Levels

The learning effect achievement level of "Description of Movement"				
Inspection level		Investigation contents	Evaluation criterion	Grade
Core	Scientific reasoning ability	Can the unit tasks be c ompleted?	H: All can be completed; M: A part can be completed; L: It's completely impossible to complete.	
	Teamwork ability	The situation of getting along with classmates in the group during the	H: Get along well; M: There are contradictions but they can be resolved;	

literacy		group discussion.	L: There are conflicts that cannot be resolved.	
	Innovative thinking	Whether the new problems in the unit tasks can be completed.	H: All can be completed; M: A part can be completed; L: It's completely impossible to complete.	
	Model construction ability	Can the complex scenarios in unit operations be abstracted into physical models?	H: The completion situation is very good; M: The completion situation is average; L: It's completely impossible to complete.	
	Sports concept	Whether the concepts such as "particle", "velocity", and "acceleration" are fully understood and correctly applied.	H: It can be fully understood and correctly applied; M: Not fully understood but can be applied correctly; L: Can't understand and can't apply it correctly.	
	Scientific attitude	Can the more difficult problems in the situation be solved?	H: It can be solved; M: Attempting to solve but in order to arrive at the correct answer; L: No attempt was made.	

Note: The achievement degree is divided into three levels from high to low: H, M, and L.

5. Conclusion

Conceptual teaching is the foundation of high school physics teaching. Only by clearly mastering physical concepts can one proceed with subsequent studies. Conceptual teaching based on the large-unit teaching concept can help students learn physical concepts better. However, it is undeniable that it is rather difficult to integrate some units, which poses a great challenge to teachers' abilities. This requires the joint efforts of a large number of educators to design better conceptual teaching plans, so as to help students better develop their core literacy and become "complete individuals" that meet the needs of social development.

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