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Transitioning from "Knowledge" to "Concept" in Problem Scenarios

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Abstract: *In current physics education, physics knowledge and physics concepts are both interconnected and distinct, which is a fact that is often overlooked by front-line educators. Based on the analysis and evaluation of Teacher Sang's lesson "Senior High School Physics Review: Energy Concept", this paper clarifies physics concepts and physics knowledge, and summarizes their relationship. It provides teaching suggestions for transitioning from "knowledge" to "concept" in accordance with the new curriculum standards and effectively fostering the development of students' physics concepts.*

Keywords: *Physics concepts, Physics knowledge, Energy view*

1. Introduction

What is knowledge? The definition given by the "Encyclopedia" published by Shanghai Dictionary Publishing House in 2014 is: Knowledge is any information stored in the human brain, used to complete learned tasks and the various complex network structures that it forms. Knowledge is acquired and refined through continuous construction and reconstruction processes in the interaction between the individual and the environment. Knowledge can generally be divided into declarative knowledge and procedural knowledge [1]. It can also be summarized as the outcome of human cognition, and a reflection of objective reality produced on the basis of practice and tested through practice. In "The Norms of Knowledge" [2], American Harvard sociologist Bell defines knowledge as a systematic elaboration of facts or concepts, which can represent a reasoned judgment or an empirical structure, and can also be disseminated to others in a systematic way through certain information tools [3]. From these literature discussions on knowledge, knowledge can be seen as a rationalized human experience, the result of human rational cognition; it is a systematic, reorganized and elaborated set of related facts. As for the concept, the "Encyclopedia" describes it as a thought consciousness, a generalized image of objective things in the human brain [4]. In other words, the concept belongs to the category of thought consciousness, a generalized image and representation of objective things in people's minds, a general term for a series of systematic viewpoints on things or the objective world, and a collection of multiple, interrelated viewpoints. Comparing the concepts of knowledge and concept, it can be found that knowledge is often associated with facts, while concepts are associated with viewpoints. As we all know, facts and viewpoints are two different types of things often encountered in daily life, and they are both distinct and interconnected. Analyzing and studying the differences and connections between the four concepts of facts, viewpoints, knowledge, and concepts is the basis for understanding the differences and connections between physics knowledge and physics concepts. As for the concept of fact, the "Encyclopedia" states: Fact has two meanings, one is the truth of the matter, and the other is the actual location of the matter. From the above analysis of the concepts of viewpoint and concept, it can be seen that the system formed by generalizing and elevating a series of related viewpoints is the concept. In other words, the concept is formed by refining and generalizing a series of related viewpoints. Figure 1 reflects the relationship between viewpoints and concepts. In this sense, concepts are subjective because viewpoints are more subjective. Overall, the relationships between viewpoints, facts, concepts, and knowledge can be summarized as shown in Figure 1.

Physics knowledge is the sum of human understanding and experience gained in the process of describing and studying the laws of change in the material world using physical thoughts, viewpoints, and methods. It is a description of the material world, consisting of numerous physical facts, including physical concepts, physical laws, and physical theories, etc. As for physics concepts, researchers have defined them from different perspectives, among which the following are representative: (1) Physics

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concepts are people's understanding and views of physical phenomena and processes, and are the rational cognition of physical phenomena and processes, that is, the physical concepts and laws formed in the minds of learners; (2) Physics concepts are the fundamental understanding of the physical world summarized by physicists through long-term practice and theoretical research. This understanding guides people to continue to explain different phenomena and predict their development rules, and evolves with the development of the physics discipline; (3) Physics concepts are the basic understanding of matter, motion, energy, and interaction, etc., formed from the perspective of physics, mainly including matter view, space-time view, energy view, and interaction view [5].

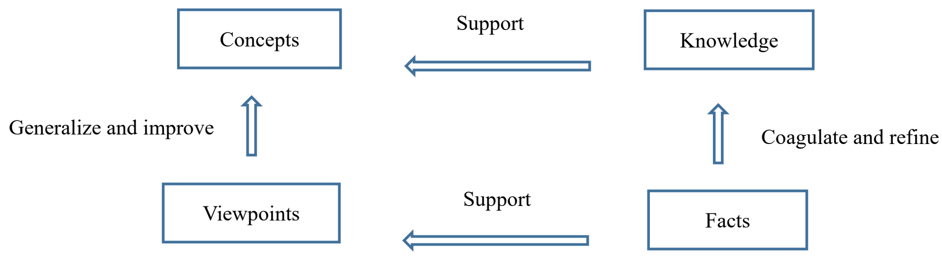

Figure 1: The relationship between viewpoints, facts, concepts, and knowledge.

The physical world is structured, and the physics concepts that reflect the material world are also structured, manifested in that physics concepts are constructed with core concepts. An important concept in physics: the energy view, which consists of views and perspectives on the existence of various forms of energy, energy conversion, energy conservation, and energy changes. These viewpoints are interrelated and support each other, forming the intrinsic structure of the energy view. It can be seen that the structure of physics concepts is formed by the physics viewpoints that make them up. These physics viewpoints are closely related and constitute the intrinsic structure of physics concepts.

2. Transitioning from "Knowledge" to "Concepts"

For Teacher Sang's lesson "Senior High School Physics Review: Energy Concept", the author lists the knowledge and concepts included in each teaching process in Table 1.

In Teacher Sang's scenario-based teaching, the transition from "knowledge" to "concept" in teaching is mainly achieved through the following aspects:

(1) The first step from knowledge to concept is to start with the origin of knowledge itself in the problem scenario. In the raindrop falling situation raised by Teacher Sang in class, he starts from the source of knowledge and gradually leads students to form concepts. "The condition for the conservation of mechanical energy is that only gravity does work," "the work done by gravity corresponds to the change in gravitational potential energy," and so on, starting from the functional relationship between the source of knowledge and the concept, teaching students to build logical connections between knowledge. Finally, Teacher Sang raises thought-provoking questions such as "Why did scientists 'create' a 'mechanical energy' concept, and what do they want to describe?" "With the law of conservation of energy, why do we still need the law of conservation of mechanical energy? Aren't they talking about the same thing?" These questions elevate the knowledge logic that students have already sorted out and established to the level of concept to review the problem. Mechanical energy is obviously related to mechanical motion. If the energy involved in mechanical motion is sorted out first, the problem should be answered. Energy exists not only in mechanical motion but also in thermodynamics, electromagnetism, and light atomic physics. If the energy in the force, heat, electricity, and light atoms learned in high school is sorted out, the problem should also be answered. The path from knowledge to concept is to find the reason for the formation of knowledge (why) and thus achieve the leap from knowledge to concept.

(2) Experiencing scenarios, analyzing scenarios, and internalizing physical concepts. The formation of physical concepts is not only cognitive but also experiential and rational analytical. Physical concepts cannot be spontaneously formed by memorizing physical knowledge but require students to deeply understand and master relevant physical knowledge in active and proactive exploration activities and form concepts through continuous generalization and refinement in the understanding and application of knowledge. This requires teachers to grasp some core concepts that can effectively form physical concepts and typical physical models that can form these core concepts, fully mobilize

students' thinking, make students deeply understand related knowledge in active and proactive exploration, and improve the overall and general level of knowledge in the mind through transfer applications in specific scenarios, thus realizing the internalization of physical concepts [6].

Table 1: The knowledge and concepts included in each teaching process.

Teaching Link	Teaching Content	Knowledge in Problem Scenarios	Concepts Held by the Questions Raised by the Teacher
Introducing Problem Scenarios	Problem and Scenario: Xiao Ming learned in a science popularization activity that as a raindrop falls from the cloud to the ground, it is subject to air resistance, which increases with increasing speed, and eventually falls at a constant speed. After learning about the law of conservation of mechanical energy, Xiao Ming conducted the following analysis: During the uniform falling process of the raindrop, the raindrop is subjected to both gravity and air resistance. Gravity does positive work on the raindrop, increasing its mechanical energy; air resistance does negative work on the raindrop, reducing its mechanical energy. The absolute values of the work done by gravity and air resistance are equal, so the total mechanical energy of the raindrop is conserved. Please state whether Xiao Ming's analysis is correct and explain your reasons.	Air Resistance Uniform Descent Law of Conservation of Mechanical Energy	"Please state whether Xiao Ming's analysis is correct?" "Explain your reasons?"
Teaching Process 1	Answer 1: When the raindrop falls uniformly, gravity does positive work on the raindrop, and air resistance does negative work on it, with the net work being zero (because the raindrop falls uniformly, which indicates that the magnitudes of these two forces should be equal). Ah? The question is whether mechanical energy is conserved? What does the mechanical energy have to do with the work done by gravity and air resistance? However: mechanical energy is obviously not conserved! "Obviously" there is a logical break. Issues in the answer: Is the conservation of mechanical energy of the raindrop related to the analysis of the work done by gravity and air resistance? If so, how can the conservation of mechanical energy be directly derived from the work done by these two forces?	Positive Work Negative Work Net Force is Zero	"Mechanical energy is obviously not conserved." "Logical Break"
Teaching Process 2	The teacher guides students to evaluate Xiao Ming's analysis process: Where is Xiao Ming's mistake?	Conservation of Mechanical Energy	"Did not identify the logical error in Xiao Ming's analysis, but just tried to solve the problem on their own."
Teaching Process 3	Question:Force+Work=Mechanical Change? Conclusion: force + workmanship ≠ mechanical energy change?	Work is a measure of energy conversion	However, the conclusion Xiao Ming drew obviously contradicts the facts, so there must be some logical inconsistency in his analysis.
Teaching Process 4	Summary: Where is the problem? Concept - Systematic knowledge: Constructing a coherent cognition of objective things. Problem - Solving problems is not just about solving questions (finding patterns, choosing formulas, and substituting calculations), but also paying attention to the problem itself and the situation in which the problem is situated.	Functional relationship	The logical connection between knowledge and knowledge is the concept. The concept focuses more on why things are the way they are and why they are so, and then uses the formed concepts to solve problems.
Teaching Process 5	Using physical concepts to explain the laws of matter and its motion Why do objects' movements show the existing laws? Use a series of systematic thinking for explanation (concept): 1.Motion and interaction concept 2.Energy concept	Laws of matter and motion	Motion and interaction concepts, and energy concepts are two very basic and important concepts. It's important to see if everyone can apply these concepts to solve problems effectively.
Problem solving		Work Internal energy Mechanical energy	So why should we also pay attention to the changes in mechanical energy? Why did scientists "create" a "mechanical energy" concept? What did they want to describe? With the law of conservation of energy, why is there also a law of conservation of mechanical energy? Aren't the two talking about the same thing?

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Teacher Sang guided students to analyze the raindrop falling scenario, let students experience it for themselves, expose students' logical breakpoints in analyzing the problem, create cognitive conflicts, and trigger students' thinking activities to explore and solve the problem. Although it is an online course, and students' mobilization situation is unknown, such strategies are already the necessary path to form conceptual classroom teaching. Teacher Sang compares functional relationships, triggering students to focus on Xiao Ming's analysis logic problem rather than directly solving the problem itself, and allowing students to pay attention to how knowledge is built in the model construction process, as well as the contradictions and cognitive misconceptions that may arise in the process. Finally, after forming the concept of energy, returning to the scenario itself, Teacher Sang's subsequent classes all practice from "knowledge" to "concept" in various scenarios like the first class.

(3) Paying attention to students' preconceptions to realize physics concept teaching should expand the current physics teaching objectives and elevate them to the level of physics concepts [7]. Physics concept teaching should be based on physics knowledge teaching and should not exclude physics knowledge teaching, because physics concepts need the support of physics knowledge, and the structure and system of physics concepts and physics knowledge are closely related. In this class, Teacher Sang reviewed knowledge such as functional relationships, force analysis, and the nature of work. Research on physics teaching has found that students have many preconceptions about energy. For example, some students think that "energy" is "force" because people need food to have strength; some students use "energy," "force," and some motion concepts interchangeably to express the concept of energy. Preconceptions are related to students' life experiences, cognitive levels, and personal development. To enable students to establish a correct concept of energy, it is first necessary to teach the concept of energy with knowledge as the carrier, and help students understand and master the concept of energy correctly. This is the starting point for physics concept teaching [8].

In the following classes, Teacher Sang helps students further clarify what points are related to the concept of energy. Although energy can be felt, it cannot be seen or touched. Therefore, the primary issue in energy concept teaching is to answer: What is energy? The answer is: energy is the ability to do work and the essence of matter, supported by the forms and transformations of energy and other physical knowledge. By addressing these points, students can construct a solid understanding of energy concepts and build upon their existing knowledge to develop a more comprehensive understanding of physics.

3. Conclusion

In summary, educators should reposition the standards of "teaching" and "learning" in secondary school physics education and include physics concepts as one of the important goals in the newly revised high school "Physics Curriculum Standards". This is because physics concepts are rooted in people's minds, and even if they forget the knowledge of physics, the corresponding physics concepts can still exist in students' minds for a long time, influencing their views of the world, behavior, and problem-solving methods. Therefore, physics concept teaching should not be judged by whether students have been "taught" and "learned" physics knowledge in the classroom, but rather by new, more comprehensive and scientific standards.

In order to better achieve the teaching of physics concepts, two possible measures can be tried: introducing open-ended question types and formative assessment. Compared with summative assessment, formative assessment focuses more on students' performance during the learning process, promoting students' overall development, discovering and tapping the potential of different students, and promoting the individual development of students. It also respects students' differences and growth patterns, and through assessment and guidance during the learning process, enables students at different levels to build confidence and make continuous progress. Furthermore, formative assessment emphasizes the importance of students' subjectivity, allowing students to participate in the evaluation process, stimulating students' intrinsic motivation, changing from "wanting me to progress" to "I want to progress", giving full play to students' initiative, improving learning efficiency, and achieving better and faster development of students. There are various methods and approaches that match the characteristics of formative assessment. Only in this way can the evaluation of students' physics concepts be realized, and secondary school physics teaching can be elevated from knowledge-based teaching to the level of physics concept teaching.

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