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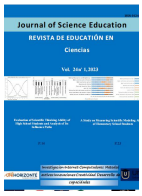

The Application of Conceptual Change in Physics Experiment Teaching: Connotation, Strategies and Cases

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ABSTRACT

Physics concept transformation is the starting point of physics learning and the key to students' independent construction of new concepts. This paper first expounds the connotation of concept transformation, then discusses the teaching strategy of concept transformation, and finally analyzes the teaching cases of concept transformation in physics experiments, in order to provide theoretical and practical reference for concept transformation teaching.

1. Introduction

Physics concept is the basis of physics knowledge system, and the concept is like the cornerstone of a subject. Whether teachers and students can understand physics concept scientifically is the fundamental of physics teaching.The learning of scientific concepts is a process in which students independently construct and understand new concepts under the social and cultural environment. The understanding deviation of students in the process of conceptual transformation is common. Teachers need to adopt corresponding teaching strategies to help students transform pre-concepts into scientific concepts.Therefore, this paper expounds the connotation of concept change, further discusses the teaching strategy of concept change, and finally studies the teaching case of concept change in physics experiment.

2. The Application of Conceptual Transformation in Physics Experiment Teaching

2.1 The Connotation of Conceptual Chang

The connotation of conceptual change can be analyzed from the four conditions of conceptual change.In 1982, Posner et al. proposed four conditions for conceptual transformation: (1) Dissatisfaction with the original concept.Only when learners are dissatisfied with the original concept in their head, feel that their original concept has lost its function, and cannot explain new events or new problems encountered at present, that is, cognitive conflict occurs, they are likely to give up the original concept and accept the new concept.(2) Comprehensibility of new concepts.Only when learners discover the meaning of new concepts and understand them can they accept new concepts.The rationality of the new concept.The comprehensibility of a new concept is seen only when it is consistent with other concepts received in the mind;(4) The effectiveness of new concepts: When new concepts can effectively explain the problems encountered by individuals, they become a better way for individuals to solve problems(Posner, Strike & Hewson, 1982).

Since then, western researchers have put forward the connotation of conceptual change from the theory of constructivism, that is, the concept of conceptual change learning.The concept change learning view holds that the concept change is the process of the change, development and reconstruction of the original concept in the students' mind, that is, the process of the transformation from the pre-scientific concept to the scientific concept.There are two different approaches to this transformation: (1) The enrichment approach, which involves the expansion of the original conceptual structure quantity.(2) Through the path of reconstruction, which means the creation of new structures, which are created to interpret old information or to explain new information(Yuan,2003). From the perspective of educational psychology, the transformation of physics concepts is to transform stubborn wrong concepts into correct scientific concepts. Before students learn physics concepts, their brains are not blank, but there are contents acquired in previous learning, life and communication, many of which are inconsistent with or completely in conflict with the understanding of things in scientific theories.This is the wrong concept in the student's mind, and the physical concept transformation is the process of transforming these wrong concepts into scientific concepts.

The connotation of conceptual change can be divided into broad sense and narrow sense. In a broad sense, conceptual change is a way

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for students to learn from preconception to scientific concept.In a narrow sense, conceptual change means that when students learn new knowledge, they change their original ideas and accept correct scientific concepts.Conceptual shift is defined as a learning process in which beliefs held by students are shifted and restructured, away from misconceptions or ideas about how the world works, and towards dominant concepts held by experts (Feng & Chen,2021).The concept change in physics is the process that the physical knowledge or concept originally in students' mind is transformed into the scientific physical concept in a certain period of time through the effective teaching of teachers.

2.2 Teaching Strategies for Conceptual Change

The teaching strategy of concept transformation is an important way and means to make students change their concepts. It is a process that teachers help students transform their pre-concepts into scientific concepts.Conceptual transformation teaching strategies are mainly carried out based on cognitivism and constructivism. Cognitivism pays attention to students' pre-concepts, stimulates students' active cognition, and proposes such conceptual transformation teaching strategies as hypothesis, demonstration, deduction, inquiry, experiment and concept map.Constructivism mainly explains the process of students' mistaken concepts and changing laws, and focuses on teaching strategies in cooperative learning and environmental construction.

At the same time, the teaching strategy of heterogeneous thinking promotes the teaching of conceptual change.Heterogeneous ideas refer to ideas that are contrary to scientific concepts, including both a wrong understanding of scientific concepts and an inaccurate or partial understanding.The teaching strategy of heterogeneous thinking is that teachers guide students' learning motivation and stimulate students' learning interest, take the initiative to create scenes conducive to the teaching content, and consciously prompt the clues of the connection between new concepts and old concepts, so as to enable students to construct a scientific knowledge system and realize the transformation of heterogeneous thinking.After the heterogeneous teaching strategy, a more specific conceptual transformation teaching strategy has emerged, which belongs to the variable teaching strategy of hypothesis strategy. In other words, Driver develops the prediction-observation-explain (POE) teaching strategy, in which students first predict the result of a problem and then explain how the result is produced.The difference between prediction and interpretation is then observed, and finally the teacher presents conceptual conflicts to help them challenge their preconceptions.In addition to hypothetical teaching strategies, inquiry strategies and guided question strategies are also conducive to conceptual transformation. The inquiry strategies conducted by teachers should stimulate students' interest and trigger cognitive conflicts.LynnErickson and LoisLanning advocate setting up more guiding questions in concept teaching, including stimulating questions, conceptual questions and leading questions (Lynn & Lois,2018). By raising questions, students can generate cognitive conflicts and contribute to the transformation of concepts.Luo Meiling also found that teaching strategies that trigger cognitive conflict among students can effectively transform the concept of myths (Luo,2013).In addition, researchers also analyze the concept change teaching strategies from the perspective of disciplinary cases. For example, based on the concept change theory, they construct scientific concepts while transforming wrong concepts through simulation activities, typical concept analysis examples, and logical problem strings and other teaching strategies (An,2016).Taking "Energy release and breath" as an example, the three-step concept transformation teaching exploration is carried out, using discussion and dialogue to trigger cognitive conflict;Carry out exploratory experiments to encourage cognitive adaptation;Construct models effectively and understand the nature of things.The three-step conceptual transformation teaching strategy transforms students' original wrong concepts and forms new scientific concepts (Gu,2018).

It is worth noting that exploratory experiment and analogy are two important teaching strategies to promote the transformation of physics concepts.The cognitive process of physical concept transformation can be divided into three steps: First, it involves four methods: concept map method, paper and pencil test method, interview method and observation method.Second, it causes cognitive conflict.Although cognitive conflict does not necessarily cause conceptual transformation, it is the beginning of conceptual transformation and the key to the process of conceptual transformation.Exploratory experiment is an important strategy to trigger cognitive conflicts among students in physics teaching. Through exploratory experiment, students can realize the inadequacies in original ideas and new phenomena that have never been discovered, so as to stimulate students' interest in learning. In physics teaching, teachers should ask students to solve the differences between different viewpoints, including those of teachers, students and books, so as to learn.Finally, the physical concept is constructed (Zhang,2008).The premise of constructing new concepts is that these new concepts must have comprehensibility, rationality and validity.After the cognitive conflict, students should construct the physical concept and realize the conceptual transformation.Therefore, in order to achieve conceptual transformation, analogy is very important. Under the premise that new knowledge and old knowledge have a certain connection, students consciously compare new knowledge with original knowledge when learning new knowledge (Posner, Strike & Hewson, 1982).For example, when students learn the properties of magnetic field, they make an analogy with the properties of electric field, when they learn elastic potential energy and gravitational potential energy, when they learn Coulomb's law, they make an analogy with gravitation.In addition, peer teaching can also be used to carry out large class teaching, in the teaching process, teachers guide students to communicate and report.

2.3 A teaching case of conceptual transformation of physics experiment

Based on the above analysis, the author designs a role-based conceptual transformation teaching case based on "Free Fall Movement", in which the teacher uses exploratory experiment and analogy teaching strategies to teach.The teaching objectives of this lesson are three: (1) Through the paper ball experiment, students will question the former concept of the same falling speed as the weight object, and form cognitive conflict;(2) Through Newton tube experiment, students were asked to observe the phenomena of how fast feathers and iron pieces fall in air and vacuum respectively, and the concept of free fall was introduced by means of exploratory experiment teaching strategy;(3) Through the dot-timer experiment, the law of free falling body movement is summarized, and then through the analogy teaching strategy, the formula of free falling body movement law is obtained according to the formula of uniform acceleration movement law, so as to realize the concept transformation.(figure 1)There are three important teaching tasks in this lesson, namely the concept and conditions of free falling motion, the concept of gravitational acceleration and the law of free falling motion.The course is divided into three parts around the concepts of free fall and acceleration of gravity, including cognitive conflict, concept introduction, concept establishment and concept analogy. It mainly uses experimental method, analogy method and scenario method to carry out concept transformation teaching.

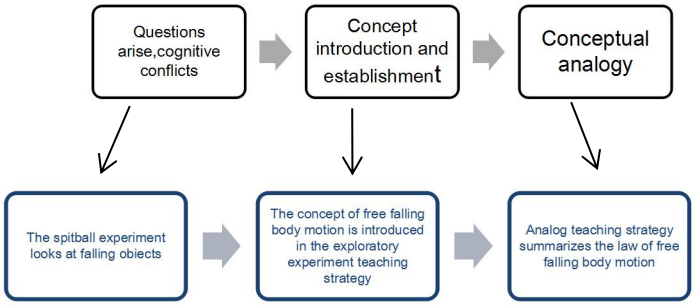

Figure 1 Free fall motion one lesson conceptual transformation teaching session

Based on the experimental concept transformation teaching strategy, the teaching process of this lesson involves three links.First, the first step is to generate doubts and form cognitive conflicts.Teacher activity 1: Show four common falling movements in life, namely falling apple, falling dew, falling snow and falling leaves.Standing on a high-rise building, let two objects of different weights fall from the same height at the same time, which object will fall faster?Student Activity 1: Students consistently answer heavy objects falling fast, and give common examples in life.Teacher Activity 2: Take out two pieces of paper of the same size in the classroom and roll one into a ball.Let the paper ball and another piece of paper fall at the same height, and let the students observe which one falls faster. In combination with the experiment and life experience, discuss what factors affect the speed of the object's fall.The design intention of this part is to explore the fall of two pieces of paper with the same weight through a small experiment. Students can observe the different falling speed of objects with the same weight, which breaks the original concept that heavy objects fall faster than light ones, causing cognitive conflict for students and providing conditions for conceptual transformation.Secondly, the concept of link two is introduced and established.The teacher demonstrated the Newton tube experiment to the students, exploring the research of how fast and slow the weight of different objects fall.The glass tube can communicate with the outside world, and feathers and iron pieces of different mass begin to fall simultaneously from above the glass tube.Next, the teacher pumped out the air in the glass tube, and the students observed the difference between the two falls of the object.Students carefully observed that when there was air in the glass tube, the iron sheet fell significantly faster than the feather, and when the glass tube became a vacuum, the iron sheet and the feather fell equally fast.The teacher can see from the experiment that after the air is pumped out of the glass tube, there is no effect of air resistance, and the light object and the heavy object fall equally fast.The reason why people see objects falling differently in real life is because of the effect of air resistance.If there were no air resistance, everything would fall the same.So the concept of free fall is the motion of an object falling from rest only under the action of the teaching process of gravity.The design intention of this part is to use the teaching strategy of Newton tube inquiry experiment to make students understand that all objects fall at the same speed without air resistance, and then introduce the concept of free falling motion.

Enter the scientific method part of the teaching of conceptual transformation again, that is, the conceptual analogy of link 3.Teacher activity 1: Guide the students to do the dotting timer experiment to explore the law of free falling motion.Student activity 1: Students do experiments to measure the acceleration of gravity fall, following the study of the motion of the car learned earlier, fix a timer, tie a heavy object to one end of the paper tape, and pass the other end through the timer.Start the timer by holding the top of the tape in your hand. When you let go, the weight falls and the timer leaves a trail of dots on the tape.Repeat the experiment by changing the weight.Teacher activity 2: Summarize the nature of the motion of a free falling body and introduce the concept of gravitational acceleration. Through the motion of a free falling body is a uniformly accelerated linear motion with an initial velocity of zero and an acceleration of g=9.8m/s2, students are asked to compare the rule formula of the motion of a free falling body.Student activity 2: According to the formula $v=v_0+at$ for uniformly variable linear motion, compare the formula v=gt for free falling motion.According to the displacement time formula $x=v_0t+\frac{1}{2}at^2$ of uniformly variable linear motion, the motion formula $h=\frac{1}{2}gt^2$ of free falling body is simulated.Finally, according to the displacement formula $v^2-v_0^2=2ax$, the free falling motion formula $v^2=2gh$ is simulated.The design intention of this part is to introduce the law of free falling motion through the timer experiment.By using the uniform acceleration motion law and analogy strategy, students can get the law of free falling motion, and finally form the concept transformation.

In short, teachers are the designers and implementer of teaching activities, and the conceptual transformation of students in class requires teachers to carefully plan corresponding teaching strategies. Scientific thinking activities such as exploratory experiments and analogies are widely used in the teaching strategies of physical conceptual transformation, which can cause students to have cognitive conflicts, establish scientific concepts, restrain false pre-concepts, and help them realize conceptual transformation.So that students can cultivate the core quality of physics more effectively.

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