METHODS OF SCIENTIFIC KNOWLEDGE AND RESEARCH IN THE CONTENT OF SECONDARY EDUCATION ON PHYSICS

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ABSTRACT

Based on a systemic approach, the content of the course of Physics can be expressed through its components, among which there are the following ones: scientific knowledge and methods of learning; questions for self–testing; exercises; assignments; examples of problem solving aimed at forming knowledge and experience of cognitive methods application in familiar situations; creative tasks for the development of the experience of theoretical and experimental research; means of motivating by the content and by the process of learning. Each type of contents implements the relationship of scientific knowledge and methods of cognition of objects at different levels of theoretical generalizations.

Keywords: General secondary education, content, system, course of Physics, kinds of contents, scientific knowledge, methods of learning, types of learning activities, experience of creative activity, motivation by content, motivation by process.

INTRODUCTION

The content of education in didactics is defined as the transfer of the social experience of society to the younger generation. In social experience, culture is embodied, the broad meaning of which1 is the socially progressive creative activity of man in all its spheres. Social experience consists of certain elements - types of content: knowledge about nature, society, technology, man, methods of cognitive activity; experience in the implementation of known methods of activity; experience of creative activity embodied in special intellectual procedures; experience of an emotional-value attitude to reality [1; 4].

In the methodology of teaching physics, these four types of content can be concretized taking into account the peculiarities of the cognitive activity of students in studying a course in high school physics. The course content is a system concept that has the following types (components):

–Scientific knowledge and methods of cognition of physics;

– Questions for self-control, exercises, tasks, examples of solving problems as a means of transmitting to students the experience of applying knowledge and methods of cognition in familiar situations;

–Creative tasks, the implementation of which requires the use of educational activities characteristic of theoretical and experimental research;

–Means of motivation by the content and process of educational activity.

The types of contents of the physics course significantly affect the development of students' intellectual and creative abilities, which are characterized by the presence of special strategies for educational activity, its individual style, highly structured knowledge, and criticality to the results of their own academic work.

DISCUSSION

Consider the types of content of the physics course on the example of the author's line of textbooks and the corresponding teaching kit in high school physics [5; 6; 7].

The first type of content "Scientific knowledge and methods of cognition" of a physics course is presented as two interconnected subsystems: scientific knowledge and methods of cognition. The subsystem "Scientific knowledge" is reflected in curricula, textbooks and teaching aids in certain forms of expression, the main of which are physical phenomena, bodies, matter, physical concepts (including physical quantities), laws, theories, and a physical picture of the world. The branch of physics - mechanics, molecular physics, electrodynamics, quantum physics - has a certain composition of scientific knowledge expressed through the above forms. Each of them has the property of consistency. For example, the presentation of educational material on physical quantity includes the following elements: the result of observing the properties of an object characterized by a physical quantity; object model; determination formula; SI unit of measure physical meaning of the quantity; measurement method; examples of use in technology. This scheme of element-wise analysis of a physical quantity is indicative, since physical quantities not only have common properties, but have their own characteristics.

So, when familiarizing yourself with the physical picture of the world in the course of the ninth grade, categories are highlighted among the concepts. They reflect in cognition the most general and essential properties of objects. Categories include concepts of law, interaction, motion, energy. In the course they are presented in specific terms of the subject, for example, Newton's laws, strong interaction, thermal motion of matter molecules, electromagnetic field energy. These forms of expression of scientific knowledge are included as elements of the above categories.

A new addition to the content type "Physical Methods of the Study of Nature" in physics textbooks is the introduction of special chapters on the methods of cognition of nature. Table 1 shows a fragment from the program of sample thematic planning of the chapter "Physical Methods for the Study of Nature" of a seventh-grade physics course [5]. This chapter is an introduction to the first-level physics course.

Table 1. Thematic planning of the chapter "Physical methods nature studies "

The main content of the topic "Physical methods of the study of nature"	Description of the student's main activities (at the level of educational activities)
Physics is the science of nature. Objects of the study of physics. Experiment and modeling are the main methods of studying nature. Physical quantities. International system of units. Measuring instruments. The density of the substance. Indirect measurements of the density of matter. The discovery of laws is the task of physics. Physical theories are a system of scientific knowledge. Physics is a developing science. The connection of physics with other natural sciences.	Give examples of objects of study of physics (physical phenomena, physical body, substance, physical field). Observe and analyze physical phenomena (record changes in the properties of objects, compare and generalize). To get acquainted with the experimental research method (reproduce, record the change in the properties of the object, analyze the results) and the modeling method (highlight the essential and secondary in the study of physical phenomena). Use physical models (material point, mathematical pendulum, model of the solar system according to Copernicus) to explain mechanical phenomena. Give examples of basic and derived SI units.

	Determine the main characteristics of measuring instruments (measurement limit, scale division price). Measure the dimensions of a flat body, taking into account the maximum absolute and relative measurement errors. Compare the table values of the density of some substances.

As follows from the table, when studying the chapter "Physical methods of the study of nature", students get acquainted with the basic methods of cognition - physical experiment and modeling. Under the method (from the Greek metod - “method of cognition”) in physics, we mean a method of activity that comes down to certain rules, techniques, norms of cognition and the totality of educational mental and experimental actions that students must complete to achieve their pedagogical goals and related tasks.

The purpose of the method is to organize and regulate the educational activities of students in physics, which are revealed in the program by describing the characteristics of the main activities. So, in the textbook the composition of one of the most important experimental methods of physics is revealed - the method of direct measurement of physical quantities, the purpose of which is to find the numerical value of a physical quantity using measuring instruments. According to the rules of their application, during the measurement process, the following types of actions must be performed: find the measurement limit and the division price of the device, calculate the absolute error, record the result of measuring the value taking into account the absolute (or relative) error.

In the chapter “Physical methods of nature research”, students only get acquainted with the methods of physical experiment and modeling (table 1). Students should learn the following activities of a physical experiment: reproduce, record changes in the properties of an object, analyze the results, measure the dimensions of a flat body, taking into account the maximum absolute and relative measurement errors. Acquaintance with the modeling method means mastering the following educational activities: to single out the essential and secondary in the study of physical phenomena, use physical models - a material point, a mathematical pendulum, and the Copernican model of the solar system - to explain mechanical phenomena.

When studying the topics of the course, knowledge and skills develop, learning activities that are characteristic of experiment and modeling are complicated. For example, the study of the theoretical law of universal gravitation involves the following actions: get acquainted with the history of its discovery, analyze the mathematical record of the law, understand the physical meaning of the gravitational constant, the conditions of applicability of the formula of the law of universal gravitation. The study of an empirical law, for example, Hooke’s law, provides for other types of educational actions than actions in the assimilation of a theoretical law. To study Hooke's law means to observe elastic deformation, experimentally investigate the dependence of the elastic force on the elongation of the body, analyze the results of the experiment, determine the limits of applicability of the law.

Introduction to the physics course of new topics on the methods of scientific knowledge, characteristics of the main types of activities of students at the level of educational actions sets a new strategy for educational activities in the lesson, which is characterized by the rapid development of educational material, the high success of its implementation; advancement of specific goals of activities due to deeper ownership of the subject.

The next (second) type of content of the physics course is the content of questions for self-control, exercises, tasks, examples of solving problems in textbooks. This type of content is a means of forming students' experience in applying the methods of cognition in familiar situations.

The solution to any problem requires the use of certain methods of cognition. Every method, including a method for solving problems, can be considered as a model of activity containing a goal, a sequence of certain educational actions and means of achieving a goal. Questions to the text of paragraphs of textbooks provide some guidance in the texts of their content; analysis of problem solving - a description of the algorithm for their solution to the application of laws and theories; fulfillment of tasks and exercises - self-control of the quality of assimilation of mental actions when solving problems in a familiar situation. So, in the paragraph "Methods for solving problems on the application of conservation laws in mechanics", a ninth-grade physics course analyzes the algorithm for solving problems on the application of the conservation law of total mechanical energy. In matters of self-control, it is proposed to talk about a system of actions in solving problems of applying the law of conservation of total mechanical energy. An analysis of an example solution to the problem reveals the steps that need to be taken to find the work of the friction force applied to the car during emergency braking until it stops completely. Tasks and exercises provide all the main types of presentation of situations: through graphs, experiment, formulas (equations), analysis of the movement of vehicles close to real conditions [8].

For the successful development of the types of educational activities, scientific knowledge and methods of cognition in high school, it is important to familiarize students with the general methods characteristic of all natural sciences and physical research methods. The study of the course of physics of the tenth grade (second stage) begins with the introductory chapter, “The Method of Scientific Cognition,” the teaching material of which is devoted to the methodological issues of physics. Students get acquainted with two basic levels of cognition of nature - empirical and theoretical (table 2). These levels are closely interconnected and significantly differ from each other. At the empirical level, sensory cognition, living contemplation directed directly at the object being studied, predominates. In empirical generalizations, rational forms of cognition are used - judgments, concepts, ideas, measurements of quantities, but they have a subordinate meaning. The studied object is reflected mainly from the side of its external properties available to sensory cognition.

As follows from table 2, the main methods of cognition characteristic of the empirical level are the collection of facts, their primary generalization, a description of the observed experimental data, their systematization and classification.

The components of the process of scientific knowledge	**Cognition levels**	
	Empirical	**Theoretical**
Purpose	Description of the physical phenomenon; properties of matter, physical field	Explanation of the phenomenon, properties of matter, physical field; event prediction
An object	Physical phenomenon; substance, physical field	The essence of the physical phenomenon, physical field, substance properties
Types of generalization (examples)	Empirical law, idea, hypothesis	Theoretical law, hypothesis, idea

Methods of cognition (examples)	Observation, description, classification, comparison, measurement	Ascent from: abstract concepts to scientific fact; an abstract understanding of theory to a concrete, more complete understanding of phenomena
General logical Methods of cognition (examples)	Analysis, synthesis, induction, deduction, modeling	Analysis, synthesis, induction, deduction, modeling

In modern science, the basic types of generalization are physical theories and a physical picture of the world as the basis of a natural-science picture. The theoretical level of knowledge and the empirical method of research are interconnected. This relationship is manifested in the fact that experience is planned and constructed by theory. An experiment represents a planned action, each step of which is guided by theory. The theoretical level of knowledge is characterized by the predominance of such forms of generalizations as concepts, laws, theories. At the same time, living contemplation, sensory knowledge becomes a subordinate but important aspect of the cognitive process. The main goal of the theoretical level of knowledge is to achieve objective truth in all its concreteness and completeness of content. To solve this problem, cognitive techniques and methods are used. These include idealization - mental objects, synthesis - integration into the system of data obtained as a result of their analysis and comparison with its other elements, deduction - the movement of knowledge from the general to the particular, the ascent of the abstract to the concrete.

It should be noted an important feature of scientific knowledge: empirical and theoretical knowledge have common logical forms of expression, for example, law, hypothesis, idea. On their basis, more complex forms of rational cognition are built - a physical theory, a physical picture of the world. Empirical and theoretical methods of cognition are also characterized by general methods: analysis, synthesis, induction, deduction, modeling (empirical and theoretical), interpretation.

In the physics course, students get acquainted with philosophical principles (methods), general scientific and often scientific methods of physics. Philosophical methods, unlike others, are not strict prescriptions, regulators of actions, but represent a system of "soft" principles, operations, techniques and are of a general nature. Thus, the principles of historicism and contradiction play the role of a method of studying nature. They are not described in strict terms of logic and experiment, cannot be formalized and mathematized.

General scientific approaches and methods are developed on the basis of general scientific concepts, for example, "model", "probability", "system", "activity". These concepts define the names of general scientific methods - modeling, probabilistic, systemic, activity approach. These methods lend themselves to formalization, refinement by means of mathematical theory, symbolic logic.

Often, scientific methods relate to specific sciences, such as physics. Such methods are the Galileo method, coordinate and vector methods in mechanics, statistical and thermodynamic methods in molecular physics [2], the principle of superposition in mechanics and electrodynamics, the Huygens principle and spectral method in optics, the probe method in quantum physics.

The creative tasks of theoretical and experimental research constitute the third type of course content. Creative assignments are a form of active educational research and construction. To

complete these tasks, the student must select the object of study, determine the theoretical model, mentally imagine the object of study and conduct a mental experiment with it. A set of statements appears that contain a description of the object of study and at the same time serve as a means of predicting the results of a real experiment. At the same time, students have ideas about the structure of research and design activity.

B.C. Stepin and L.M. Tomilchik in the scientific knowledge of physics distinguish layers of model schemes that define the object of study. These schemes include empirical schemes, primary models of theoretical explanation, schemes that lie in the foundation of developed theories [3].

If we take the objects of their research as the basis for classifying tasks, then all tasks can be divided into three groups: 1) empirical, 2) theoretical explanation tasks, 3) tasks, model schemes of which are the foundation of developed theories - mechanics, molecular physics, electrodynamics, quantum physics.

Empirical tasks include those that use special models of the empirical level of knowledge. In research tasks of this level, the experiment is schematized by replacing real objects with empirical model objects, for example, in the form of diagrams, drawings, drawings of an experimental setup. In the assignment, such models are provided with some description. An example of the first group is a creative assignment from a ninth-grade physics course (table 3).

The model objects in this problem are the electric circuit, the research circuit, and the figure. They reflect the connections and interactions of the components of the model scheme of empirical explanation, as well as the results of mental experience. The second group includes tasks of theoretical explanation, in which mental experience on ideal models acts as an object of study. Consider an example of the second group of tasks (table 3).

The solution to this problem is reduced to a model explaining the action of the flashlight. This model is based on the phenomenon of electromagnetic induction. In this case, abstract objects are used: “conductors”, “lines of magnetic induction”, from which a model of theoretical explanation is built. The dynamic model of the theoretical explanation is reflected in the relations between the objects: the appearance of an induction current in a closed loop – coil when the magnetic flux changes. An explanation model formed in this way acts as a thought experiment performed on a system of abstract objects. This model uses the typical features of a demonstration and virtual experiment in a lesson in the process of working with a textbook and computer models.

Table 3: Tasks of theoretical explanation

Job Classification	Task Example
Application Tasks empirical schemes	Identify the poles of the poles of an electric battery on which they are not marked. At your disposal there is the following equipment: a lamp on a stand, a piece of wire, a compass, an electric battery - a direct current source. Develop a research plan, make explanatory drawings and write down your project - research in the lesson.
Tasks for the application of primary theoretical models explanations	There are designs of flashlights, where a capacitor is used as a current source, which is connected to a wire coil. Inside the coil is a magnet that can move in it. When shaking the flashlight, the magnet moves. If you turn on the flashlight, the light bulb connected to the capacitor lights up.

	What energy conversions do this happen? What phenomenon is the effect of the flashlight based on?
Tasks for the application of models that are the foundation of developed theories	The problem solved by G. Galilei: "The speeds acquired by the same body when moving along equal inclined planes are equal if the heights of these planes are the same ..." Prove the correctness of this statement. Under what condition is it fair?

The creative tasks of the third group are tasks whose model schemes are the foundation of developed theories. An example of the task of this group is the task of the heading of the textbook "From the History of Physics": the problem solved by G. Galilei.

The scheme for explaining the result of the study of this assignment lies in the foundations of Newtonian mechanics. It is built as a model. The components of this model are abstract objects - power, energy, material point, isolated system of bodies, as well as the law of conservation of energy. The model summarizes the types of training actions for moving bodies along an inclined plane.

The means of motivation by the content and the process of educational activity belong to the fourth type of course content. The classification of motivation tools is based on the idea of the products of educational activity: the development of scientific knowledge and methods of scientific knowledge. The structure and content of educational material, encouraging students to strive to learn new facts, can serve as a means of motivation. So, in the textbooks, substantive lines on: the history of physics and technology are highlighted; familiarization with technical objects; design and assembly of laboratory facilities; performing frontal and home laboratory work; the use of information tools, including computer support.

For students with increased cognitive need in textbooks, an approximate topic of educational projects is given. So, in a ninth-grade physics course, the topics of projects are grouped into the following groups: from the history of the development of physics, experiment and modeling — the main methods of studying nature; practical applications of physical knowledge.

The textbooks present material that is aimed at the formation of an emotional-value attitude to nature and to himself, and to each other. For example, in a seventh-grade physics course, a theoretical justification is given to an important road behavior rule for a person — why you cannot cross the road in front of fast-moving vehicles. In the eighth grade course, students get acquainted with precautions when working with electrical appliances and measures of protection against overloads of the electrical network.

Examples show that the activity of mastering the content of physics can be considered as a whole as a polymotivated activity. The motives inherent in the educational activities in physics are related to the content that stimulates the desire to master the scientific content and methods of cognition, and this means to theoretically explain the physical phenomena occurring in the macro-, micro- and mega-world.

CONCLUSION

The process of cognition of concepts, laws and theories can also become a leading motive for activity. Performing laboratory research, getting to know fragments of the work of physics classics, discussing modern achievements of science and technology, discussing and assessing

the problems of design work, using didactic games is an important means of motivating the learning process.

Thus, the content of the physics course is a systemic concept that includes certain types that realize the relationship of scientific knowledge and methods of cognition. The types of content represent scientific knowledge and methods of cognition; tools that convey the experience of applying knowledge in familiar situations and in educational creative activities; methods of motivation by the content and process of educational activity. Each type of physics course content reflects the interconnection of scientific knowledge and cognition methods.

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