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Formation of meta-subject knowledge and skills in the process of training in physics in the secondary school

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The meta-subject approach implies translation of the educational content not as information to remember, but as knowledge ready for application. Through it basic skills in students are developed: thinking, imagination, goal setting, understanding, action [1–3].

A technological model is presented, based on the application of the meta subject approach in the physics training in the secondary school. The practical value of the model is that the theory and practice of the training in physics are enriched with new ideas for the formation of meta subject knowledge, and respectively skills of the students.

The technology we offer can be used for studying in all the sections of physics in the secondary school.

Its implementation would allow a real increase in the quality of the learning process in physics through work with the students' abilities.

Key words: meta-subject, physics, an activity approach, systematization

INTRODUCTION

The objectives of modern education are related to training, development and education of free humane individuals, enriched with scientific knowledge of nature and humans, capable of and ready for creative activity and moral behaviour. In view of achieving these objectives, the results of education may be considered in three aspects: subject, metasubject and personal. The metasubject results involve students' acquisition of universal educational activities (UEA), applicable both within the educational process and in real-life situations. UEA may include educational motives (personal UEA); educational purposes (regulatory UEA); learning tasks (cognitive UEA); educational activities and operations (regulatory and communicative UEA). Mastery of the UEA system appears to be a necessary basis for the overall subsequent development of learners.

In physics laws and natural phenomena are studied, which provide great opportunities for transfer into real-life situations. That is why the teaching of physics is a favourable field for the application of the meta-subject approach.

Application of the meta-subject approach in the training of physics involves work with the students' abilities, namely: ability to work with concepts. ability to systematise; ability for graphic representation of study information. ability to understand and schematise the condition of a task, modelling the object of the task, design of ways for solving it, etc.

DESCRIPTION OF THE TECHNOLOGY

Our main objective is to construct a technology model, based on the idea for the realization of the meta-subject approach in physics training.

We consider the expected results in view of the formation of meta-subject knowledge, respectively skills which, in turn, is connected with qualitative and thorough absorption of physical knowledge. Meta-subject knowledge are about:

- planning an educational-cognitive activity for studying a physics section;
- summarised plans for studying a physical law, physical phenomenon, physical quantity, physical device;
- an algorithm for carrying out observations and experiments in the course of individual activity;
- work in a team;
- self - assessment of self activity.

An essential component in the proposed by us technology is the planning of the educational-cognitive activities by both the teacher and the students. This approach places students in an active role. Originally, they are trained to analyse an unknown topic by a certain plan. Then they proceed to planning an in-depth study of the topic. The teacher discusses with students the way of formation of new knowledge, of synthesis and systematization of knowledge, control, self-diagnosis. Then follows compilation of questions on the topic and the allocation of tasks be-

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tween students in project activity. The students in groups are also allocated tasks for systematising of the learning material. Students also carry out observations and experiments by a specified algorithm in the course of individual activity.

Students are trained to analyse a forthcoming section by the following plan:

1. Determination of the objects for studying - physical quantities, physical processes, physical phenomena.
2. Determination of the means for description of the objects of study - laws, theories, models.
3. Determination of the objects for application of physical knowledge - machines, appliances, equipment, generators, motors, etc.
4. Determination of classifications existing in the topic, indicating classification characteristics.

We offer a definite example of this plan in the study of section "Heat phenomena" in the eighth grade.

Objects for study

- Physical quantities – internal energy of an ideal gas, temperature, amount of heat, work done on a gas or by a gas.
- Physical phenomena – heat exchange, melting, solidification. evaporation, condensation.
- Physical processes – isothermal process, isobaric process, isochoric process.
- Physical principles – first law of Thermodinamics, second law of Thermodinamics.

Means for description the objects

- Physical laws - the law of Boyle and Mariotte, Gay - Lussac' s law, Charle' s law.
- Physical theories - kinetic theory, thermodynamic theory
- Physical models - ideal gas, model for structure of substance in solid state, liquid state and gas state.

Classifications

Isothermal process $T = const$; Isobaric process $p = const$; Isochoric process $V = const$.

For the organization of the study information systematization it is necessary that the students know and apply the summarised plans for studying the physical quantity, physical law, physical phenomenon, physical theory, physical device [4]. We present this information follows:

Summary plan for physical quantity

1. Name and symbol.
2. Physical meaning.
3. Formula.
4. Units for measurement.

Summary plan for physical phenomenon

1. External characteristics of the phenomenon.
2. Descriptive definition based on the external characteristics.
3. Conditions for emergence.
4. Examples for observation of the phenomenon.
5. Experiments for demonstration of the phenomenon.
6. Quantities, concepts and laws wich describe the phenomenon.
7. Models for research.
8. Explanation of the phenomenon based on modern scientific theories.
9. Application of the phenomenon in the practice.

Summary plan for physical law

1. Physical phenomena wich characterized the law and relation between physical quantities wich concider the law.
2. Conditions for validity of the law.
3. Limits of the applicability of the law.
4. Presentation of the law – with words, with formula, with table, with graphics.
5. Presentation of the physical meaning of the law.
6. Examples for application of the law in the practice.

Summary plan for physical theory

1. Basic facts for creation of the theory.
2. Areas of the applicability.
3. Basics of the theory.
4. Phenomena, facts and laws wich the theory explains.
5. Phenomena, facts and laws wich the theory predicts.
6. Historical information for creation and developing of the theory.

Summary plan for physical device

1. Name and use.
2. Appearance and characteristics.
3. Marking scheme.
4. Principle of operation.
5. Main parts and their use.
6. The rules for work with device.
7. Application in the science, technics and practice.

Table 1. Physical quantities in the section "Heat phenomena"

Physical quantity	**Denotation**	**Physical sense**	**Definition**	**Formula**	**Units of measurement**	**Means and devices for measurement**
Temperature	T	Characterizes the property of heatedness	A scalar physical quantity characterizing a given thermodynamic state under certain outside conditions	Thermodynamic approach: $pV = \frac{m}{\mu}RT$ $\frac{p_1}{p_2} = \frac{T_1}{T_2}$ Statistical approach: $T = \overline{E_K}\frac{2}{3k}$	K	Thermometer, thermo-couple, thermistor, gas thermometer, etc.
Work done on a gas or by a gas	A	Characterizes the change of volume under the action of forces; the change of energy of the gas or other bodies	A scalar physical quantity whose magnitude at fixed pressure is defined as the product of the pressure and the change of volume of the gas	Work by outside forces to contract the gas: $A = p\Delta V$ Work by outside forces to expand the gas: $A = -p\Delta V$	J	Indirectly by measuring the pressure and volume
Internal energy of an ideal gas	U	Characterizes the movement and interaction between the molecules of the gas	A scalar physical quantity whose magnitude is defined as a sum of the kinetic energy of the chaotic movement of the particles and the potential energy of the interaction between them	Statistical approach: $U = N\frac{3}{2}kT$	J	Indirectly, by measuring T $U = N\frac{3}{2}kT$
Amount of heat	Q	Quantitatively characterizes the process of heat exchange	The energy that a body receives or gives away during heat exchange with its surroundings	$Q_{giv.} = cm(t_1 - t_2)$ $Q_{rec.} = cm(t_2 - t_1)$	J, cal 1 cal = 4.18 J	Calorimeter

We present definite example of the summary plan for physical quantities in the section "Heat phenomena" (Table 1).

Knowledge of summarised plans allows students to ask individual questions, and the teacher to organize communicative, reflexive and cognitive activity, in the process of which the students systematise knowledge.

During individual observations and experiments students follow the algorithm:

1. Select the necessary equipment/materials/.
2. Install set of experiment.
3. Demonstrate experiment and comment by the following plan:
    - What hypothesis is verified with the experiment.
    - What equipment is selected and why;
    - What is observed in conducting the experiment;
    - What can be deducted from the results of the experiment.

The teacher organizes assimilation of metasubject knowledge during the lessons in physics using work in groups, work in pairs, didactic games, etc.

Meta-subject knowledge appears to be a matter of control by the teacher and self-control by the students. Acquiring metasubject knowledge, students compile control questions on the topic. In the process of reflexive activity they formulate difficulties, which are then successfully overcome in the process of training.

CONCLUSION

Formation of meta-subject knowledge and skills is an extremely important process for the training in each school subject. They are necessary for the organization of all types of school activities: cognitive, communicative and reflexive. The Importance of the meta-subject approach in education also consists in this, it allows you to store and maintain the culture of thinking and the culture if formation of the scientific worldview of the students.

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ФОРМИРАНЕ НА МЕТАПРЕДМЕТНИ ЗНАНИЯ И УМЕНИЯ В ПРОЦЕСА НА ОБУЧЕНИЕ ПО ФИЗИКА В СРЕДНОТО УЧИЛИЩЕ

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(Резюме)

Метапредметният подход в обучението предполага транслиране на учебното съдържание не като сведения за запомняне, а като знания за осмислено прилагане. Чрез него се развиват базови способности у учениците като мислене, въображение, целеполагане, разбиране, действие [1-3].

Представен е технологичен модел, основан на прилагането на метапредметния подход в обучението по физика в средното училище. Практическата ценност на модела се състои в това, че теорията и практиката на обучението по физика се обогатяват с нови идеи за формиране на метапредметните знания, респективно умения на учениците.

Технологията, която предлагаме може да се използва при изучаване на всички раздели на физиката в средното училище.

Прилагането ѝ би позволило реално да се повиши качеството на учебния процес по физика чрез работа със способностите на учениците.

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