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Implementation of the System Approach in Continuing Natural Science Education

Implementación del enfoque sistémico en educación continua en ciencias naturales

Svetlana Alexandrovna VOLKOVA 1; Polina Dmitrievna VASILIEVA 2; Victoria Stanislavovna TUGULCHIEVA 3; Tatyana Vitalyevna KHONDAEVA 4

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ABSTRACT:

The research is devoted to an important problem of subject didactics. The aim of the work consists of the investigation of realization effectiveness of system approach in the continuing Natural Science education. The development of Natural Sciences has actualized the problem of systematic knowledge formation among pupils and Natural Sciences students of higher educational institutions which is directly connected with the increase of volume and complexity of educational material, growth of its uncertainty and innovativeness. In the terms of internationalization and continuity of contemporary education, different preparedness of school-leavers for studying at the higher educational institution the role of comprehension of educational material by various categories of students increases. The search for new technologies is held, new kinds of activity, experience appear and thus the content of education and forms and ways of its mastering are renewed. The technology of didactic unit consolidation which includes the development of reversed problems and also the set of other interlinked tasks is the most optimal way of facilitating the pupils and students' comprehension of operation calculation in chemistry.

RESUMEN:

La investigación está dedicada a un importante problema de didáctica de asignaturas. El objetivo del trabajo consiste en la investigación de la efectividad de la realización del enfoque sistémico en la educación continua en Ciencias Naturales. El desarrollo de las Ciencias Naturales ha actualizado el problema de la formación sistemática del conocimiento entre los alumnos y estudiantes de Ciencias Naturales de las instituciones de educación superior, lo que está directamente relacionado con el aumento de volumen y complejidad del material educativo, el crecimiento de su incertidumbre y su capacidad de innovación. En los términos de la internacionalización y la continuidad de la educación contemporánea, la preparación diferente de los que abandonan la escuela para estudiar en la institución de educación superior aumenta el papel de la comprensión del material educativo por varias categorías de estudiantes. Se lleva a cabo la búsqueda de nuevas tecnologías, aparecen nuevos tipos de actividad, se experimenta y, por lo tanto, se renueva el contenido de la educación, las formas y las formas de su dominio. La tecnología de consolidación de unidades didácticas que incluye el desarrollo de

In the article there is generalized a long-term experience of using of this technology in Natural Sciences teaching. Teaching methods and techniques common for subjects of Natural Sciences module are offered: the method of comparison and early opposition; the technique of educational information transformation, the technique of direct problem solving and making up of reversed problems. Transformation of tasks is considered to be the means of achievement of subject and metasubject results of Natural Science education.
Keywords: System approach, continuing Natural Science education, interdisciplinary links, technology of didactic unit consolidation, transformation of tasks, inverse actions and operations, direct in reversed problems.

problemas invertidos y también el conjunto de otras tareas interrelacionadas es la forma más óptima de facilitar la comprensión de los alumnos y los alumnos sobre el cálculo de la operación en química. En el artículo se generaliza una experiencia a largo plazo del uso de esta tecnología en la enseñanza de Ciencias Naturales. Se ofrecen métodos y técnicas de enseñanza comunes para los sujetos del módulo de Ciencias Naturales: el método de comparación y la oposición temprana; la técnica de transformación de información educativa, la técnica de resolución directa de problemas y la creación de problemas invertidos. Se considera que la transformación de tareas es el medio para lograr los resultados de sujeto y metasujeto de la educación en Ciencias Naturales.
Palabras clave: enfoque sistémico, educación continua en ciencias naturales, vínculos interdisciplinarios, tecnología de consolidación de unidades didácticas, transformación de tareas, acciones inversas y operaciones, problemas directos en reversión

1. Introduction

One of the main problems of contemporary system of education is the disunity of subject methods of teaching which prevents mastering of basic Natural Science concepts and systematic mastering of educational material. The renewal of the content and teaching methods of Natural Science subjects at school and at higher educational institutions must be implemented with the system approach (Gerus 2013).

The aim of any subject teaching is known to be the provision of students' comprehension of the material studied which can be revealed by the skill of establishing links between components of knowledge and thereby comprehending the essence of the subject. The objects of Natural Sciences studies are the changing nature with its deep connections between qualitative and quantitative regularities.

Among Natural Sciences Chemistry and Physics are characterized by the deep interlinked, experimentally checked and self-corrected content. Thus, for example, a chemical reaction is the unity of opposite processes: the break of links in initial substances and the formation of news ones in reaction products. During Chemistry teaching objects with opposite properties are studied: acids and bases, oxidant and restoratives, metal gaining and metal corrosion, processes in a galvanic cell and electrolyzer. Methods of chemistry are the ones of the analysis and synthesis which also are the basic logical operations. In Natural Sciences teaching it is necessary to regard the systematic character of the processes studied. The implementation of direct and reversed operations such as the solution of direct problems and making up the reversed ones within one class facilitates understanding of latent interconnections between qualitative and quantitative parameters of chemical processes. While solving a reversed problem, students can check the results of the direct one and revise made operations and calculations, understand latent, implicit information. Systematic character of objects studied by chemistry isn't fully regarded during teaching of Natural Sciences module subjects.

During Mathematics teaching academician P.M. Erdniyev substantiated scientifically methodical ideas of pupils' systematic knowledge formation. These ideas are widely used in teaching of Natural Sciences, including Chemistry. Developing the technology of didactic unit "consolidation" the scientists relied on the fundamental regulations of thinking, facilitating the optimization of cognitive processes (Erdniyev 2009). Classification of training tasks into direct and reversed operations is based on the revealed regulations of information flow passage along the closed path (P.K. Anokhin). Regarding of psychological aspects of remembering and chemical information mastering becomes a significant factor of educational material comprehension. From the point of view of modern scientists "comprehension is the skill of juxtaposing of a given phenomenon and a certain visual image and then a conceptual or mathematical model which must be simple and obvious" (Shcherbakov 2007).

2. Research methods

Methods of research were chosen according to the tasks solved at its separate stages. In the process of research there were used the following methods: the analysis of didactic and methodical literature and educational practice at secondary and higher school with regards of world tendencies of educational development; comparative analysis of pedagogical experience concerning implementation of the approach oriented at knowledge and the competency one in Chemistry teaching; system analysis of concepts, categories and phenomena; forecasting, projecting, modeling/ At the empirical level there were used: experimental testing of the developed methods of teaching in the terms of contemporary information environment of the school and the higher educational institution; pedagogical observation, interview, questionnaire, testing, pedagogical experiment; studying and generalizing of own and advanced pedagogical experience on the researched problem. There were used methods of statistic processing of experimental data results; numeric and graphical presentation of information and its methodical analysis.

3. Findings

The technique of opposition of studied objects properties by means of educational information folding in graphic, symbolic and other kinds is implemented successfully by teachers within block-module method of education. The review of task structure during Natural Science teaching demands changes of educational process organization where the central elements are tasks. While structuring of tasks into problem transformation for provision of students' comprehension of its text form, important operative actions should be made.

The main idea of this technology is that the tasks are not isolated from each other but connected with the plot and are solved not as separate units but as an integrated task in the frames of the lesson. The composition of tasks for the Chemistry class includes:

- usage of direct and reverse operations on the bases of one and the same theoretical material;
- their formulation with the usage of methods of comparison, contrast, experimental check.

At practical classes including the solution of system of problems students are offered not only simply to analyze the problem solution but also transformation of the initial task in a reversed way by means of the substitution of known variables into calculated ones. Therefore, the solution of the initial problem and development of other tasks on its base facilitates development of students' necessary associations and stable temporal links in Chemistry. Besides, the search of inverse problems, the search of logical sequence of operations and work with ones and the same quantitative variables facilitates their revision together with simultaneous usage of two ways if education: rational, based on cause-and-effect relations, and additional intuitive.

Traditionally, Chemistry teaching at school and university supposes the problem solution made up by authors of textbooks, and they as usually are grouped according to the types according to algorithms offered for their solution. However single-type tasks make mistaken impression that students have successfully gained knowledge of the taught set and skills necessary for solution of such problems. For revealing of comprehension of inner interlinks between qualitative and quantitative parameters of chemical processes we offer the following structure for creation of tasks and their solution: solution from given "basic" problems the second one, the reversed one, the third and the following ones (Vasilyeva and Emtsova 2013). Thus, the traditional approach to the solution of problems is limited by the search of solutions without their check in class, and also by their solution in accordance with given algorithms.

Let's illustrate the transformation of the problem in the frames of system approach which can be recommended for the teaching of the theme "solution" at different stages of education.

Problem 1 (direct). Solubility of ammonium iodide in water at the temperature of 30 degrees

C is 181.7 g in 100 g of water. Calculate the weight fraction of ammonium iodide in the solution saturated at given temperature.

Problem 2 (reversed). Weight fraction of ammonium iodide in total mass saturated at 30% is 64.5%. Calculate the solubility of the salt at given temperature.

The solution of direct and reversed problems facilitates in pupils of necessary associations and stable temporal connections in Chemistry. Besides the search of solutions of reversed problems, the search of logic operation sequence, work with ones and the same quantitative variables facilitate its revision with simultaneous usage of two ways of teaching: rational based on causal relations and additional intuitive transformation (Vasilyeva and Tugulchiyeva 2014).

It is noteworthy that in the context of calculative chemical problems there are reflected types opposite in essence: concerning the identification of the substance composition on the basis of reactant masses or volumes, combustion product mass and volume; concerning making solutions according to the given concentration and identification their quantitative composition; concerning identification weight fraction of the chemical element in the compound according to its formula on the basis of this parameter. The combination of direct and reversed actions while solving the problem facilitates student's comprehension of quantitative regularity and latent information. Each of the made problem is an independent unit of educational material and teaching. For example, such types of problems are given in the article (Vasilyeva and Emtsova 2013). Retries made within short periods of time facilitate prolonged memorizing of the material and provide its further application in educational situations. At the same time educational information is produced in different forms.

Federal State Educational Standard of general education emphasizes making chemical equations and making calculations on their basis as one of subject competencies. We recommend solving complex problems in the context of which there is demanded not only to make the equation of oxidation-reduction reaction but also to derive the formula of organic substance according to the information about its composition, to define its structure and also to make calculations in accordance with chemical equations. Our big experience of school practice shows that the analysis of such problems allows individualizing of teaching, developing cognitive interest and creative abilities of pupils.

Problem 3. Solid carbon A and liquid carbohydrate B have one and the same empirical formula and contain 92.3% of carbon in mass. The solution A in B doesn't decolorize bromine water. While interacting of 52.0 g of this solution with acidulous solution of potassium permanganate there was formed a single organic product – benzoic acid to naturalize which 72.1 ml of 10% of sodium hydroxide (ρ = 1.11 g/ml) was necessary. Identify the structure of substances A and B and find the weight fracture of A in the solution (Volkova 2017).

In all spheres of life, we face with functional dependence. The idea of function is formed in pupils while studying the school programme in Mathematics and continues with function research by methods of differential calculation and making their graphs at the first year of Bachelor course. Types of functions are studied within the school programme in Mathematics successively. Skills of building and searching of functions laid in the secondary school are applied in further professional education in the course of which there takes place consolidation of mathematical concepts formerly gained at school, such as: the variable quantity, functional dependence, the function, the range of definition, the extreme point, and also there is formation of new ones: function continuity, function convexity, asymptote. While revision and generalizing of the system of "function and its properties" special attention was paid to the ways of setting the function:

- by words (the rule of function setting is described by words);
- analytical (the function is set by the formula);
- graphical (the function is set by the graph);
- by the table (the table where values of the function for finite set of argument value are given).

For revealing of conduction of different educational information forms presenting on Figure 1 we made the investigation of the initial students' knowledge level, given data were processed statistically and presented in the article (Tugulchiyeva and Vasilyeva 2017).

Figure 1
Linear function

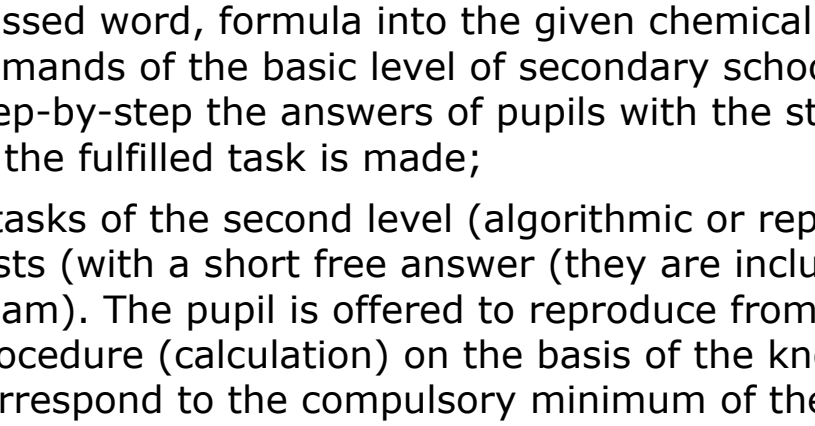
By words

The automobile moving at constant speed of 70km/h covers S km during t hours

Analytical

S=70t

Graphical



Table

t, h	0	1	2	3	4
S, km	0	70	140	210	280

4. Discussion

When the world of knowledge, the ideal world, the world of ready cognitive products prevails as the object of studies in contemporary educational space of the school and the higher educational institution it leads to the substitution of real objects by ideal ones – concepts, laws, facts. It means that the student making investigation doesn't study real objects of surrounding world but gains given knowledge about it. The situation when the aim of school is to equip the growing generation with the cultural heritage of the society specified the priority of knowledge paradigm. The leading tendency of contemporary school is reorientation of educational process from "teaching" to "learning", strengthening of its activity character, increasing of using opportunities of educational results in life (Mirenkova 2014).

In school practice three kinds of tasks according to three levels of mastering are used:

• tasks of the first level (introduction, differentiation, activity according to recognition) are tests on identification (with choice of the answer); if the demonstrated object or phenomenon belongs to objects or phenomena of the given kind; tests on differentiation: the choice of one decision from the list of possible ones; tests with substitution: insert the missed word, formula into the given chemical test. Tasks of such type corresponds to the demands of the basic level of secondary school-leavers' knowledge in Chemistry. Comparing step-by-step the answers of pupils with the standard ones the conclusion about the quality of the fulfilled task is made;

• tasks of the second level (algorithmic or reproductive activity is done) are the constructive tests (with a short free answer (they are included into the first part of the Unified State Exam). The pupil is offered to reproduce from memory this or that information, to do the procedure (calculation) on the basis of the known formula, algorithm. Tasks of such type correspond to the compulsory minimum of the content high level of secondary (complete) school;

• tasks of the third, creative, level (productive, heuristic activity) are non-type problems demanding knowledge application in new situations, i.e. their creative transfer (tasks with the detailed free answer, they are included into the second part of the Unified State Exam). The content of these tasks corresponds to the most complex tasks of traditional tests in General, Inorganic and Organic Chemistry of secondary (complete) school.

Implementation of the system approach in continuing Natural Science education is done in accordance with the principle of content minimization. We study different phenomena on the

minimum set of typical objects considered in different aspects. In order to heighten pupils' cognitive interest to the subject in the terms of information environment it is necessary to include qualitative and calculation problems into the content of Chemistry lessons. We single out the following methodical techniques and organizational forms for the implementation of system approach in continuing Natural Science education with the aim of renovation of content and methods of teaching Chemistry:

• application of problem technologies (calculation and qualitative problems including experimental ones the solution of which is based both on qualitative and quantitative experiment) (Volkova 2018);

• conducting practical classes in the form of mini-research or a project (Volkova and Tarakanova 2017);

• wide usage of digital educational resources in education (video-films, video-experiments, video-lectures, video0lessons, chemical experiment combining both computer and natural ones) (Volkova 2018).

The process of problem comparing is accompanied by discussing their development stages, correct text making up and right rethinking of chemical processes connected with them. The process of problem making up becomes interactive because the final variant of the problem is made in the course of discussion in the groups and analysis of its content. To define the moment of students' understanding of problem decision course is a difficult problem. This latent information is not always revealed by students because of their individual educational styles. Nevertheless, students' satisfaction from fulfillment of tasks is obvious if they are interested in making more complex tasks, and also in the way they use gained knowledge and skills in doing their own research.

Pedagogues of Kalmyk Republic use technologies of didactic units consolidation at different stages and levels of education at schools and higher educational institutions. Long experience of using technologies at schools in the Republic has shown its advantage over traditional ways of teaching.

5. Conclusion

Thus, tasks concerning independent problem making up as the means of practical implementation of theory must be included into the structure of Natural Science teaching as one of the conditions of system approach implementation in continuing education. Transformation of problems, presenting it in different forms help students understand rational character of action sequence while mastering calculation skills that means getting system knowledge in the field on Natural Sciences. Projecting of teaching technologies in the terms of nowadays educational reality must be anticipated by system analysis of the existing situation, usage of available reserves, investigation and assessment of social expectations and demands of the society.

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1. The Federal State Budget Scientific Institution "Institute for Strategy of Education Development of the Russian Academy of Education", 105062, Makarenko street, 5/16, Moscow, Russia. E-mail: volkovaismorao@gmail.com

2. The Federal State Budget Scientific Institution "Institute for Strategy of Education Development of the Russian Academy of Education", 105062, Makarenko street, 5/16, Moscow, Russia. E-mail: vasilyeva_pd@mail.ru

3. The Federal State Budget Scientific Institution "Institute for Strategy of Education Development of the Russian Academy of Education", 105062, Makarenko street, 5/16, Moscow, Russia. E-mail: tugvicky@yandex.ru

4. The Federal State Budget Educational Institution of Higher Education "Kalmyk State University named after B.B. Gorodovikova", 35800, Pushkin street, 11, Elista, the Republic of Kalmykia, Russia. E-mail: tatyana.khondyaeva@mail.ru

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