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Principles of Modern Methods for Achieving Educational Results in Natural Science Subjects

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Abstract. Organizational and methodological patterns of assimilation of natural scientific information have been identified and implemented in teaching. The specifics of perception of natural scientific information by boys at the psychological, cognitive and behavioral levels in the conditions of an already functioning separate educational institution are taken into account. The identified organizational and methodological patterns made it possible to formulate and implement in teaching the principles of modern methods of achieving subject-specific educational results, to increase the motivation and self-esteem of students. These principles include: the use of pedagogical tools and technologies, taking into account the characteristics of education in separate educational institutions; the use of modern technologies and teaching methods aimed at increasing motivation to learn and the formation of productive thinking, taking into account the specifics of the natural science field of knowledge; integration of traditional technologies for teaching natural science subjects with digital educational technologies, mainly for independent work and in extracurricular activities.

INTRODUCTION

In modern conditions of transformation of university natural science and technical education [1], which affected the training and retraining of teachers of natural science subjects [2,3,4], the attention of teachers is especially focused on meeting the requirements of the educational standard of the new generation for natural sciences. scientific results of training in educational institutions.

At the same time, there are publications in the pedagogical literature [5,6], where attention is focused on the existing features of the assimilation of educational natural science information by boys and girls, which should be taken into account in order to fulfill uniform requirements for learning outcomes. We are talking about the need to take into account the psychological, cognitive and behavioral differences between boys and girls in education. It is common knowledge that boys and girls think and perceive information differently. However, as accurately noted in studies [5,7], in lessons, methods and techniques for teaching subjects that are universal for both sexes are used. As a result, Kolechkova [5] believes, boys often either lose interest at the beginning of the educational information presented, or make mistakes compared to more diligent and accurate girls. Even with a separate form of education for gifted students, as noted in [6].

There are enough difficulties in teaching natural science subjects. There is absolutely insufficient research focused on cognitive didactics [8] and differentiated teaching [9] in natural science subjects, taking into account the organizational and methodological patterns of teaching in single-sex classrooms. Difficulties of a theoretical and

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methodological nature in the activities of teachers with different experience are pointed out by G. F. Biktagirova et al. in the study [10]. The difficulties noted above are very relevant for teaching physics, chemistry and biology in separate general education institutions - in lyceums for boys and gymnasiums for girls, which is associated with the specifics of the natural science field of knowledge.

Physics, chemistry and biology belong to natural science subjects, where the role of abstract theoretical concepts, calculations and experiment is great. For general education, the formation of initial natural science concepts, a culture of natural science experimentation, and the ability to carry out calculations using formulas and chemical equations is significant.

A contradiction arises between the need to fulfill the unified requirements of the new generation educational standard for subject educational results and the insufficient development of the principles of modern methods for achieving them in educational institutions of a separate educational process. The discovered contradiction determined the formulation of the research problem. Namely, the research problem lies in the need to identify the principles of modern methods for achieving subject-specific educational results based on established organizational and methodological patterns of assimilation of natural scientific information by students in educational institutions of a separate educational process.

The authors of this publication do not consider the pros and cons of separate science education in relation to teaching in mixed classes. The authors consider the proposed study as one of the possible attempts to find ways to solve the identified problem, taking into account the specifics of the perception of natural science information by boys at the psychological, cognitive and behavioral levels, as well as to find ways to increase academic performance, self-esteem and motivation to study natural science subjects in an already a separate educational institution that has been operating for many years.

Purpose of the study is to identify the principles of modern methods for achieving subject-specific educational results, taking into account the organizational and methodological patterns of assimilation of natural scientific information by students using the example of teaching chemistry at a boarding lyceum for boys.

MATERIALS AND METHODS

The research is based on the application of a system-activity approach, which underlies the educational standard of the new generation. The use of a system-activity approach in this study allows us to focus on modern educational technologies and digital educational resources, taking into account the identified patterns of teaching natural science subjects (chemistry) in classes formed only of boys, in order to achieve their educational results. The indicated approach allows us to take into account the peculiarities of learning at the psychological, cognitive and behavioral levels, to convey to students an awareness of their subjectivity and the need for active cognitive activity. Thus, contributing to the identification of the principles of modern methods for achieving subject-specific educational results, taking into account the organizational and methodological patterns of assimilation of natural scientific information by students in accordance with the requirements of the educational standard of the new generation using the example of teaching chemistry.

The main experimental work to identify and implement the principles of modern methods for achieving educational results in chemistry was carried out at boarding school No. 7 for boys in the city of Kazan. Testing of the research results also took place in general educational institutions of the city of Bukhara.

RESULTS AND DISCUSSION

The results of the study made it possible to formulate the principles of modern methods for achieving educational results in natural science subjects using the example of teaching chemistry in lyceums for boys. At the same time, a set of pedagogical means and technologies was considered that activate the mental activity of students in order for them to achieve educational results.

The first principle is the use of pedagogical tools and technologies, taking into account the characteristics of education in separate educational institutions.

There is no doubt that in order to achieve subject-specific educational results, one must first convey educational information to them in an accessible manner in accordance with the gender and age characteristics of students, involving them in active cognitive activity and awareness of their subjectivity, then carry out adequate control of assimilation.

To identify the organizational and methodological patterns of explaining new material to boys and monitoring its assimilation, we will consider the psychological and pedagogical features of assimilation of natural science information.

In general, the patterns of assimilation of natural science information (including chemistry) by boys can be summarized at the psychological, cognitive and behavioral levels, which brings us closer to achieving the goal of this study.

The more developed right hemisphere, which is typical for boys, is activated, as is known, when analyzing visual images and recognizing the shape and structure of objects. This fact determines the activity of abstract thinking (important for the assimilation of abstract natural science concepts), objective assessment and self-esteem. As a result, boys adapt more easily to external learning conditions. However, they are characterized by short-term memory and difficulty in overcoming a stressful situation. These are characteristics of boys on a psychological level. The cognitive level of features includes the dominance of high speed of processing new information and a synthetic approach in the qualitative analysis of search and educational material They are characterized by a rational approach in their ability to generalize and a preference for the dialogue and discussion form of project-learning activities, as well as a quick concentration of attention. Behavioral characteristics are associated with a preference for humane relationships in joint educational and cognitive activities, which is due to the predominance of optimism and openness in communication and a clear visual-spatial perception of reality. Further, based on the characteristics of cognitive didactics and thinking characteristics noted in studies [6,11], organizational and methodological patterns of teaching chemistry to boys were identified, which were subsequently implemented in the experimental part of this study. Namely, when explaining new material, maintain a fast pace of presentation, recalling the time limit and the possibility of quickly completing interesting experimental work; when summarizing and consolidating educational material, increase the share of search and creative experimental tasks, apply elements of competition, regularly simulate situations of independent educational and research activities; evaluate the outcome of learning, not the method of obtaining it. In addition, according to Latypova [12], to the identified organizational and methodological patterns of achieving subject educational results when teaching chemistry to boys, one should add the use of figurative forms of presentation and clarity, a practice-oriented approach to the study of educational material; ensuring a high level of independence and specificity in formulating tasks.

The patterns described above were taken into account in this study when developing technological maps for studying various topics of the school chemistry course and specific lessons to achieve subject-specific educational results.

For example, in the author's technological lesson maps, the emphasis is on creating educational situations of success, expanding the possibilities of independent empirical search activities of students. These are theoretical and experimental tasks to predict the chemical properties of a substance based on the structure of its molecule, identifying the main patterns of changes in properties, genetic relationships between classes of substances, identifying the reasons for differences in the properties of certain substances, followed by analysis, experiment and comparison with reference data. Upon completion of the search activity, self-reflection takes place to search for logical errors and gaps in knowledge.

Regarding the organizational and methodological principles of the developed result-oriented assessment system, the following was obtained. When assessing the performance of creative tasks in the subject, emphasis should be placed on creativity and new solutions, which increases interest in the chemical field of knowledge. The lesson as a whole is structured so that the search engine.

The students' activities were aimed at a specific result, and not just at mastering the execution of actions according to a given algorithm.

For example, when mutually testing the acquired chemical knowledge at the end of the lesson, lyceum students independently select the necessary qualitative reaction to experimentally confirm (or deny) the presence of, say, an aldehyde group in the substance under study, and formulate conclusions about the chemical properties of aldehydes in comparison with ketones.

At the same time, there is a direct dependence of the success of training on the level of requirements that a general education institution places on students. Otherwise, for successful studies, boys need both the opportunity to realize their creative potential and a disciplinary framework. Consequently, a variety of creative and highly complex tasks must be combined with a high pace of learning in the lesson and control of subject mastery, focused on the final result.

In lessons and extracurricular activities for boys, individual assignments with a strict time limit are good (for example, no more than 5 minutes to solve).

For example, in 1 minute you need to find the answer to questions such as: What acid is always found in the stomach of a healthy person, and if there is a deficiency, is it used as medicine? Which nitrogen oxide is used in medicine to relieve pain shock during operations? Specify the building material of a protein molecule.

The five-minute tasks were related to small calculation problems where it was necessary to calculate, for example, the actual yield of a product during a certain reaction.

The second principle is the use of modern technologies and teaching methods aimed at increasing motivation to learn and the formation of productive thinking, taking into account the specifics of the natural science field of knowledge.

As a result of the comparative analysis, it was revealed that the above-mentioned psychological and educational-behavioral patterns identified in boys require attention when choosing educational technologies. The technologies most consistent with the organizational and methodological patterns of teaching boys are problem-based learning and the development of productive thinking (the ability and ability to independently discover knowledge) At the same time, one should take into account the specifics of chemical knowledge (they occupy a central place in the triad: physics - chemistry - biology, which actualizes the implementation of interdisciplinary connections and the deductive method of cognition; in chemistry the role of experiment is great, which affects the structure of the lesson and actualizes the use of project-based and practice-oriented training).

Below, depending on the topic being studied, are examples of problematic questions aimed at developing students' productive thinking in the process of mental and real experiments.

For example, in individual assignments for 10th grade students on the topic "Aromatic hydrocarbons," the question is formulated: "What is the structural formula of the liquid and the equation for its polymerization reaction, if it contains only hydrogen and carbon atoms (the chemical properties of the liquid are partially disclosed in the problem statement)?" On the topic "Chemical properties of aldehydes and ketones" - a problematic question: "Indicating the signs of reactions, describe how substances can be experimentally recognized in unlabeled flasks using only solutions of copper(II) sulfate and sodium hydroxide?"

For 11th grade students when studying the topic "General methods of obtaining metals. The concept of metallurgy" formulates a problematic question: "Why did aluminum, being the most expensive metal, suddenly become the cheapest and most accessible metal? Indicate the most common aluminum-containing minerals and give their chemical formulas."

The third principle is the integration of traditional teaching technologies with digital educational technologies, mainly for independent work and extracurricular activities.

The identified organizational and methodological patterns in teaching chemistry to boys justify the widespread use of digital resources with virtual and video experiences, as well as practice-oriented classes that involve independent individual and group search work of students.

For example, digital resources such as the Google Classroom platform have proven themselves; a collection of digital chemical video experiments; Quizizz app; YaKlass platform; lessons from the best teachers presented on the platform of the Russian Electronic School or on the YouTube channel "MEKTEP OnLine Chemistry".

The following are tasks, the implementation of which requires the integration of knowledge and skills obtained as a result of traditional technologies for teaching chemistry, and skills formed through digital educational technologies. In tasks 1 – 2 below, it is necessary to justify the solution found using an experiment from the existing database of digital video experiments.

Task 1. Indicate the factors influencing the shift of equilibrium to the right in a specific reaction (optional) that occurs with the release of heat (An example of a possible answer depending on a specific reaction: an increase in the concentration of starting substances and pressure, a decrease in temperature).

Task 2. Indicate the hydrolysis products of a specific salt (of your choice) and the acidity of its aqueous solution. (An example of an answer depending on a specific salt, for example, potassium carbonate: potassium bicarbonate and potassium hydroxide are products, alkaline environment).

Completing other tasks (for example, on the topic "Chemistry in the life of society"), combined into the "Tell, show, explain" group, involves developing presentations on a specific topic with a time limit: no more than 15 minutes to complete the task and prepare the presentation, for defense – no more than 5 minutes.

Thus, as a result of the implementation of the formulated principles, it is possible to implement the identified organizational and methodological patterns of teaching chemistry, aimed at practice-orientedness, the effect of novelty, elements of a competitive nature and competition, independence and leadership in the dynamic cognitive activity of boys in lessons and extracurricular activities in chemistry (relevant didactic games, quests, etc.).At the same time, it should be recognized that information offered at a high pace causes poor assimilation due to the inclusion of

short-term memory. Consequently, increased attention is needed to the stage of repetition, consolidation and summing up the completed educational material.

Experimental main testing of the principles of modern methods for achieving educational results identified and formulated in the study based on established organizational and methodological patterns of teaching chemistry to boys in separate educational institutions (taking into account observation and comparison with the education of girls in boarding school No. 4 of the Kirov district of Kazan) , has been carried out since 2020 at boarding school No. 7 in the Novo-Savinovsky district of the city Kazan in grades 10–11. In total, taking into account the comparative observation, 103 people participated. When statistically processing experimental data, Student's t-test was used. In addition, the formulated principles of modern methods have been partially tested in educational institutions in the city of Bukhara.

The experimental part of the study included four stages: observations and comparisons, ascertaining, formative and control. At the stage of observation and comparison of education in separate general educational institutions (in a boarding school for girls and a boarding lyceum for boys), the psychological, educational and behavioral characteristics of boys were identified and confirmed, and patterns in their assimilation of chemical information in comparison with girls organizational and methodological patterns of teaching chemistry to boys were formulated, which were taken into account in the developed technological maps, practice-oriented tasks of a problem nature, extracurricular activities and other experimental material for subsequent stages determination of the dominant hemisphere; diagnostics of learning motivation and emotional attitude to learning (methods of Ch. D. Spielberg and A. D. Andreeva adapted for the study of chemistry). In addition, the average grade point for the class in chemistry (based on the test results) and self-assessment of academic performance (based on the results of the questionnaire) were determined. The ascertaining stage made it possible to determine the leading type of thinking (84% of students - with a predominance of the right hemisphere type - spatial-figurative), level of motivation to study chemistry (level 3 out of 5, corresponding to slightly reduced cognitive motivation), academic performance and quality of knowledge in chemistry. The goal of the formative stage was to increase the level of educational results, self-assessment of academic performance and motivation to study chemistry among students in the experimental group. This stage was associated with the implementation of the identified principles of modern methods for achieving educational results in chemistry.

The final control stage allowed us to obtain positive results. This stage requires some explanation. Since the average grade point of the class in chemistry was determined based on the results of intermediate and final tests, we consider it appropriate to give an example of detailing the subject results in chemistry determined in the tests, indicating the numbers in the corresponding test materials.

Below are the subject results in chemistry, measured by the final test in grade 11, where tasks 1, 3, 6, 7, 9, 11 are on knowledge of the most important chemical concepts, basic laws and theories of chemistry, basic methods of scientific knowledge used in chemistry: observation, description, measurement, experiment. Tasks 4, 9, 11 – to determine the valence, oxidation state of chemical elements ion charges; type of chemical bonds in compounds and type of crystal lattice; the nature of the environment of aqueous solutions of substances; oxidizing and reducing agent; belonging of substances to various classes of inorganic and organic compounds; homologues and isomers. Tasks 5, 11 – on the characteristics of s-, p- and d-elements according to their position in the Periodic Table of Chemical Elements by D. I. Mendeleev; general chemical properties of the main classes of inorganic compounds, properties of individual representatives of these classes; structure and chemical properties of the studied organic compounds.

Tasks 2, 3 – to explain the dependence of the properties of chemical elements and their compounds on the position of the element in the Periodic Table of Chemical Elements by D. I. Mendeleev; the nature of the chemical bond. Tasks 6, 7, 8, 9, 10, 12, 13 – to explain the dependence of the properties of inorganic and organic substances on their composition and structure; the essence of the studied types of chemical reactions; compiling equations for reactions of the studied types. Tasks 8, 13, 14 – for planning and conducting an experiment to obtain and recognition of the most important inorganic and organic compounds, taking into account acquired knowledge about the rules of safe work with substances in the laboratory and at home. Tasks 14, 15 – on the ability to carry out calculations using chemical formulas.

In the experimental group, compared with the control group, encouraging results were obtained. The average grade point increased by 0.60 units (in the control group an increase of only 0.43 units was recorded); the level of self-assessment of academic performance in chemistry increased from 4.00 to 4.46 points (no significant changes were recorded in the control group); motivation to study chemistry increased in 48% of students (in the control group - 24%).

It should be noted that, according to Barannikov et al. [13], in world practice there is no difference between the concepts of “educational results” and “subject results”. Accordingly, the requirements for educational results vary depending on the content and specifics of the academic subject.

In the Russian educational standard of the new generation [14], subject educational results are considered as educational results, including those mastered by students during studying an academic subject, skills specific to a given subject area, types of activities to obtain new knowledge within the academic subject, its transformation and application in educational, educational-project and social-project situations, the formation of a scientific type of thinking, mastery of scientific terminology, key concepts, methods and techniques. Bakhmutsky [15] draws attention to the fact that the definition of subject results contains "types of activities to obtain new knowledge within the framework of an academic subject and its transformation (p. 39)", as well as the formation of a scientific type of thinking, which increases the significance of subject educational results for the development and education of students According to the educational standard [14], subject educational results in chemistry of secondary general education include:

1. the formation of ideas about the place of chemistry in the modern scientific picture of the world; understanding the role of chemistry in shaping a person's horizons and functional literacy for solving practical problems;
2. mastery of fundamental chemical concepts, theories, laws and patterns; confident use of chemical terminology and symbols;
3. mastery of the basic methods of scientific knowledge used in chemistry: observation, description, measurement, experiment; ability to process, explain the results of experiments and draw conclusions; willingness and ability to apply cognitive methods in solving practical problems;
4. developed ability to give quantitative estimates and carry out calculations using chemical formulas and equations;
5. knowledge of safety rules when using chemicals;
6. the formation of one's own position in relation to chemical information obtained from various sources.

The educational results in a specific subject specified in the standard determine the direction of the selection of educational resources (modern pedagogical technologies, digital educational resources, laboratory equipment) used in the process of teaching chemistry to achieve them.

Research by scientists [16,17] has scientifically proven the frequently encountered thinking patterns and educational and behavioral characteristics of students depending on gender. These features have been analyzed and discussed in detail in studies [12,18]. The need for differentiated application of teaching methods, taking into account the differences of students, is discussed by Kalatskaya et al. in the monograph [9].

It should be made clear that this study is not about the need for separate chemistry education for boys and girls. In other words, in the questions and tasks proposed for teaching boys, there are no ones that could not be used when teaching chemistry to girls, since the educational standard is the same.

The authors only propose to emphasize and more often use in lyceums for teaching boys (these lyceums have long existed in the educational systems of different countries) those pedagogical means and technologies that activate mental activity, which make it possible to take into account the specifics of boys' perception of natural science information in order to increase their academic performance and self-esteem and motivation to study chemistry.

CONCLUSION

Organizational and methodological patterns of assimilation of natural science information by boys were identified and implemented in teaching, which made it possible to formulate the principles of modern methods for achieving educational results using the example of teaching chemistry in classes staffed only by boys. The specifics of perception of natural science information by boys at the psychological, cognitive and behavioral levels are taken into account to increase academic performance, motivation and self-esteem in the conditions of an already functioning separate educational institution.

Such organizational and methodological patterns include dynamism and spatial calculated natural science tasks and exercises, regular modeling of situations of independent educational and research activities, inclusion of elements of competition and competition in the educational process, tolerance to the design of individual experimental tasks, active encouragement of productive activities in the classroom. Strengthening the emphasis on practice-orientation, repetition, consolidation and summing up the completed educational material with an increase in the share of search and creative experimental tasks.

The identified organizational and methodological patterns made it possible to formulate and implement in teaching the principles of modern methods for achieving subject-specific results, to increase motivation for studying chemistry and self-esteem of students. These principles include: the use of pedagogical tools and technologies, taking into account the characteristics of education in separate educational institutions the use of modern technologies and

teaching methods aimed at increasing motivation to learn and the formation of productive thinking, taking into account the specifics of the natural science field of knowledge; integration of traditional technologies for teaching natural science subjects with digital educational technologies, mainly for independent work and in extracurricular activities.

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