

Scientific Herald of Uzhhorod University

Series "Physics"

Journal homepage: <https://physics.uz.ua/en>

Issue 56, 2757–2767

Received: 11.01.2024. Revised: 21.05.2024. Accepted: 04.07.2024



DOI: 10.54919/physics/56.2024.275do7

How tasks of an integrative nature contribute to the implementation of the worldview ideas of high school students in the subject of biology

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Abstract

Relevance. Integration of various fields of knowledge is a prominent trend in modern education, particularly within the natural sciences. At Nazarbayev Intellectual Schools, fostering a holistic scientific worldview and developing students' abilities to synthesize information are key educational objectives.

Purpose. This study aims to compare the effectiveness of three methods of knowledge evaluation in promoting a holistic natural science worldview among high school students. It seeks to determine which evaluation methods most effectively enhance cognitive processes.

Methodology. The study involved 95 students from grades 11 and 12 in Nazarbayev Intellectual Schools in Kyzylorda, focusing on chemistry and biology. A pedagogical experiment was conducted where students were assessed using three methods: standard tests, integrated tasks aligned with the Nazarbayev Intellectual Schools Educational Program, essays requiring interdisciplinary knowledge.

Results. The study revealed that students in both grades successfully completed all types of tasks, but their performance was notably higher on the integrated tasks and essay assessments compared to standard tests. The statistical analysis confirmed significant differences between the methods, indicating that integrated tasks and essays better facilitated the activation of students' cognitive processes and associative thinking. Student feedback showed a preference for integrative tasks in an open format over traditional testing.

Conclusions. The findings suggest that integrative tasks and essays, which require students to draw on interdisciplinary knowledge, are more effective in fostering a holistic natural science worldview and enhancing cognitive engagement than traditional testing methods. These methods improve knowledge retention and encourage deeper understanding by linking concepts across different scientific disciplines. The study recommends the adoption of these integrative approaches in the teaching of biology and other natural sciences. Future research should focus on further refining these methods to strengthen interdisciplinary connections and support the development of advanced natural science thinking in high school students.

Keywords: integrative tasks; science education; interdisciplinary connections; students' competencies; world outlook.

Suggested Citation:

Shazhanbayeva S, Kurmanbayev R, Ibadullayeva S. How tasks of an integrative nature contribute to the implementation of the worldview ideas of high school students in the subject of biology. *Sci Herald Uzhhorod Univ Ser Phys.* 2024;(56):2757-2767. DOI: 10.54919/physics/56.2024.275do7

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Introduction

School education sets itself several goals, which consist in the qualitative preparation of students for entering higher educational institutions, the acquisition by students of a wide range of educational competencies, as well as the formation of a holistic world outlook. The education system of Kazakhstan is constantly being reformed to optimally achieve these goals. The transition to 12-year education, an earlier choice of specialization, and deepening of interdisciplinary connections contribute to the optimization of education to meet the requirements of preparing schoolchildren for further educational and professional activities [1].

Nazarbayev Intellectual Schools set itself the goal of modernizing and optimizing curricula in accordance with the world's leading educational and scientific trends, while preserving the traditions and best practices of the past. One of the largest educational projects is STEAM (science-technology-engineering-art-mathematics) – the integration of all areas of knowledge into a single scientific picture of ideas about the world around. Within the framework of such a broad meta-subject integration, interdisciplinary integrations of related sciences are mandatory stages. In Western science and education, the concept of science is used, which combines the natural sciences: biology, chemistry, physics, medicine, as well as many related fields [2].

The traditional standards of the education system of the Republic of Kazakhstan suggest the fragmentation of sciences, as a result of which knowledge is fragmented and inapplicable in real life, as a result of which the level of knowledge after graduation is steadily declining due to lack of demand and inability to apply this knowledge. The goal of integrative education is the formation of a holistic picture of the world and the motivation of schoolchildren for the practical application of knowledge, the development of research, logical analysis and information integration skills.

Analyzing integrative approaches, V.V. Osipov and T.P. Bugaeva [3] emphasize that they allow students to improve the following competencies: subject; metasubject; research; analytical; adaptive. All this leads to the formation of global competencies that reflect the general level of knowledge, skills, relationships when interacting with the outside world and is expressed in the world outlook of the subject. World outlook is a system of views on the objective world, society and a person's place in it. J. Klabak [4] focuses on the fact that the natural science world outlook gives the student ideas about the structure of the living world, the nature surrounding it, their interactions and the place of people in this system. The listed skills and competencies are united by the concept of functional literacy, and determine the student's ability to apply the acquired knowledge.

There is the Program for International Student Assessment (PISA) in the world now, one of the areas of which is the natural sciences [5]. The program is supervised by a number of international educational organizations and is used to monitor the level of education and intellectual development in different countries [6-9]. In Nazarbayev Intellectual Schools, the subject of biology is taught taking into account the requirements of this

program and using tasks of a problem format. It has developed its own Nazarbayev Intellectual Schools Educational Program (NIS-Program) that meets the international A-Level standard. It allows entering any university in the world.

Thus, there is an understanding that the high school program in science subjects should be developed with maximum consideration for the need to form a holistic world outlook. While the schoolchildren of elementary and secondary schools master individual elements of knowledge, deepen their understanding of each branch of science, all this knowledge should be intellectually combined into a single system in high school. An integrative approach can be applied at all stages of the pedagogical process: preparatory (analysis of methods, development of curricula); main (conducting lessons, setting up practical and laboratory work); final (knowledge evaluation).

It is also possible to integrate any components of the didactic process: goals, principles, methods. In this paper, the effectiveness of the integrative approach at the stage of knowledge consolidation was investigated. The study of scientific and pedagogical literature showed a good development of the theoretical substantiation of the need to introduce integrative learning elements into the practice of secondary schools. In natural sciences (biology, chemistry, physics), sufficient research material has been accumulated on the introduction of integrative methods both at the training stage [10-12] and at the stage of knowledge evaluation [12-13]. Relevant is the study of further practical application of such methods, their development and analysis of effectiveness in the learning process. Integrative tasks are aimed at generalizing knowledge on the subject, updating knowledge in related disciplines, developing skills in technological and creative thinking.

L. Shestakova [14] gives criteria, by which one can assess the degree of formation of natural science thinking, paying attention to knowledge of the material, the ability to apply skills, evaluate one's own knowledge and motivation for learning. Authors also relied on these criteria when assessing the formation of world outlook. The goal of the paper was a comparative evaluation of different types of standard and integrative tasks in terms of the effectiveness of revealing the level of knowledge and understanding the integrity of natural science concepts according to the developed methods and criteria. The following tasks were set in accordance with the goal:

1. Development of integrative tasks to consolidate the material covered in two versions: the first option is the traditional narrowly-focused tasks of the test format; the second option is classes with interdisciplinary communication.

2. Conducting a pedagogical experiment on thematic knowledge evaluation using integrative tasks of own design.

3. Comparison of the influence of different methods of knowledge evaluation on the development of skills in natural science thinking.

Literature Review

The requirements for modern education are due to several factors that are dynamically changing the entire education system. They include a change in the ways of obtaining and disseminating information, as well as an increase in the amount of knowledge in all areas. As a result, the content and structural component of higher and vocational education is constantly changing: the emergence of new subjects, an increase in the volume of studied material, and the transfer of a significant amount of material to self-study (transition to the Bologna system).

Accordingly, the requirements for school education also change. It is necessary that students learn the material within the framework of the program, as well as acquire the skills of its synthetic transformation, understanding the essence of processes and being able to solve practical and scientific problems [6; 13]. To this end, numerous programs are used to integrate the natural sciences into the school curriculum. Integration involves sharing material or summarizing knowledge from different areas of knowledge [4].

To develop methods and techniques for integrative learning, international programs (STEAM, PISA) are being introduced that contribute to the dissemination of modern educational techniques among teachers in the global world, as well as form international standards for interdisciplinary education that undergo rigorous peer review and selection [15]. The PISA program for international student assessment was launched in 2000 and has brought together a large number of countries. Tasks allow to reveal the level of subject knowledge in the natural sciences, as well as the level of development of other cognitive abilities that reveal the ability of students to scientific research and engineering activities [16].

Many researchers point to the high positive effect of the use of integrated methods of teaching and knowledge evaluation on learning outcomes. Zh.V. Belyaeva [12] develops and tests methodologies for integrated teaching of biology, chemistry and physics in the experiments. The high efficiency of the application of these methods is shown and research lessons as well as hobby group on project activities are recommended, maps of topics and activity-semantic schemes are introduced.

L.T.K. Oan [17] conducted research on the introduction of interdisciplinary links of physics, biology and chemistry in teaching high school students the basics of molecular physics in Vietnam. Examples of a lesson on the study of new material and a lesson on solving problems in molecular physics using the material of related disciplines are given. It is demonstrated that these approaches form the systemic nature of natural science thinking help explain natural phenomena. Ya.A. Abakumova [18] singles out 84 general educational skills of high school students (organizational, intellectual, informational, communicative) and demonstrates the positive impact of integrative tasks on the development of most of them.

It is worth touching on the essence of interdisciplinary connections in the context of understanding their psychological and physiological nature. The learning process itself comprises several stages. They include mastering the basic skills necessary for further assimilation of knowledge (language, writing, counting), the acquisition of general ideas about the world (literature,

creativity, nature, language) and the concretization of knowledge, the accumulation of associative knowledge about different areas of own views [19]. According to this concept, interdisciplinary connections, corresponding to a more general idea of the world, should be acquired earlier than highly specialized knowledge in various subjects.

N.P. Romanchuk [20] proposes a neural network simulation to model the physiological role of interdisciplinary connections. According to the theory of neural networks, each knowledge is a module (represented by a certain number of neural connections). The modules are interconnected by modular links and are arranged in accordance with increasingly complex levels. The first modular level is represented by basic skills (subconscious use), the second, higher one, is the interdisciplinary level (general concepts, skills, abilities), which are also acquired at the level of attitudes and are little subject to conscious use; and the third is knowledge in specific areas of knowledge. The third level is the result of conscious efforts to remember and comprehend facts, these are the most complex, specialized and easier-to-forget information patterns. Active accumulation of knowledge on the third modular level is possible at the stage of formal operations according to Piaget – 11 years and older [19]. Thus, interdisciplinary connections are a deep component of education and precede the accumulation of knowledge in narrow areas of knowledge. The task of the teacher in this case is to activate these connections, help to understand them and use them to build a holistic world outlook.

Materials and Methods

The research was conducted among students of grades 11-12 of the Nazarbayev Intellectual Schools in chemistry and biology in the city of Kyzylorda. 95 students of 11th and 12th grades were studied. The study was designed as a pedagogical experiment of both a comparative and educational type, in which knowledge was consolidated in three stages at the end of the topic. At the first stage, students were offered an open task – to write an essay on topics of authorship. This type of evaluation was carried out after studying the first 11.1B: Cell Biology unit of topics of grade 11, and 12.1C: Molecular Biology of grade 12. As a final task on the topic, students were asked to write a short essay (up to 2 pages) on the following topics and revealing the indicated key questions:

1. Grade 11. All eukaryotic organisms have a cellular structure. Why couldn't life develop like this without cellular organization? What molecules make up cellular organelles? What classes of substances do they belong to? How is this related to their functions? Indicate how physical factors affect the functions of cells and form their diversity in multicellular organisms.

2. Grade 12. Bioorganic molecules – how life originated on their basis? What levels of organization of living beings do you know? What factors contributed to the complexity of living systems and the emergence of new levels of organization?

Before writing an essay, students were asked to make a brief mind map of their answer in order to systematize knowledge on the proposed topic. This was to help them focus on the material. It was assumed that students should demonstrate the following knowledge and skills in their answers:

- knowledge of the subject material on the topics of the "Biology" course;
- understanding the principles of organization of living systems, their chemical unity;
- awareness of the dynamism of living systems and the influence of physical environmental factors on their development;
- updating knowledge on organic chemistry and chemistry of bioorganic molecules as well as on the sections of forces in nature, thermodynamics, oscillations and waves of physics;
- the ability to think associatively, to use previously acquired knowledge to describe new phenomena;
- the skill of organizing material and highlighting what is the most importance, the inclusion of non-linear thinking when compiling mind maps;
- an open form contributes to the development of a verbal-logical style of thinking and a coherent presentation of the material, which is necessary for a modern student; this form of work simultaneously solves educational (repetition of material), development (working out cognitive skills), pedagogic (formation of ideas about the integrity and importance of nature) tasks.

The following system for evaluating the content of creative work was developed to objectify the process of evaluating and the most complete reflection of the essence of natural science understanding:

1. Compliance with the topic (3 points).
2. Answers to all questions (3 points).
3. Factual correctness of the subject material (10 points).
4. The presence of correct examples and the correct formulas of biological molecules (3 points).
5. The presence of correct examples from physics, correct names of phenomena, correct use of terms (3 points).
6. The presence of a general conclusion about the unity of processes in wildlife and the role of each of the sciences in their description (3 points).
7. The presence and compliance of the mind map with the content of the essay – consistency, observance of hierarchical relationships, completeness of the reflection of the material (5 points).

At the second stage, the ability to apply knowledge in solving practical problems was tested by completing open-format integrative tasks according to the NIS-Program. The integrated tasks developed according to standard A of the NIS-Program in the form of open questions were used.

The evaluation concerned materials 11.4B: Evolutionary Development and 12.3C: Laws of Inheritance and Variations. Each task consisted of 3 questions requiring a detailed answer. The correctness, completeness of the answer and the presence of examples, if necessary, were evaluated according to the criteria given in the collection. According to the criteria for assessing tasks, each task was evaluated at 10 points, and the maximum score for the work was 30 points.

The third type of control was carried out in a test format, based on the materials of the topics covered. These were 11.3D: Regularities of Heredity and 12.1A: Ecology.

At the end of each type of work, a survey was conducted among students on attitudes towards the task and self-assessment in its implementation. Students filled

out descriptor questionnaires that reflect their own attitude to the task and the quality of its performance by the student. The questionnaire contained the following statements:

1. The assignment was difficult/easy for me.
2. After the performance, my mood improved/worsened.
3. In my opinion, I succeeded/failed the task.
4. The assignment helped/didn't help me make new connections that I hadn't thought about before.
5. I like/dislike that knowledge testing performed in this way.
6. In my opinion, this form of evaluation develops/does not affect my overall level of development.

Students received 1 point for each positive and 0 points for each negative answer. Thus, the most positive attitude to the test was expressed in a 6-point assessment. This survey was conducted anonymously, in order to avoid the desire to please and the fear of evaluation, but only for the purpose of a screening study of attitudes towards this type of activity.

According to the results, a comparison was made of the subjective assessment by students of the two types of work performed, as well as a comparison of the objective results of work performance assessment. The results of the evaluation of each work on these items were entered into an electronic form, which facilitated the processing for each student, as well as for the class in general. Mathematical and statistical data processing was carried out using Microsoft Excel. To assess the significance of data differences, the nonparametric Mann-Whitney test was used.

Results

Analysis of the results of grade 11 descriptors showed that all students expressed a fairly high interest and satisfaction with the test results. The average self-esteem score in the control group that completed the test task was 4.45 ± 0.8 . Most often, there were negative answers to the questions of Descriptor No. 4 – "The task did not help me make new connections that I had not thought about before"; No. 6 – "In my opinion, this form of control does not affect my overall level of development". Both variants of integrative tasks were highly rated by students. The average score for the essay was 5.6 ± 0.58 . Negative answers were found among the questions of Descriptor No. 1 – "The task was difficult for me"; No. 3 – "In my opinion, I failed to complete the task". The difference with the test control was significant ($p \leq 0.05$). The average score for open questions in the NIS-Program was 5.15 ± 0.73 . Negative answers were found among the questions of Descriptor No. 1 – "The task was difficult for me"; No. 3 – "In my opinion, I failed to complete the task". The difference with the test control is significant ($p \leq 0.05$). As you can see, integrative tasks were rated higher by students, despite the subjective difficulties encountered in their performance.

In grade 12, the results were quite similar, except that the integrative essay items and the designed integrated items had close scores of 5.45 ± 0.69 and 5.25 ± 0.72 , respectively. The students described the difficulties that arose as negative answers to questions 1 – "The task was difficult for me"; No. 3 – "In my opinion, I failed to complete the task". The test evaluation item was

significantly lower and amounted to 4.55 ± 0.99 ($p \leq 0.05$). Difficulties in completing the task were expressed in the following negative answers: No. 3 – "In my opinion, I failed to complete the task"; No. 4 – "The task did not help

me make new connections that I had not thought about before" (Figure 1).

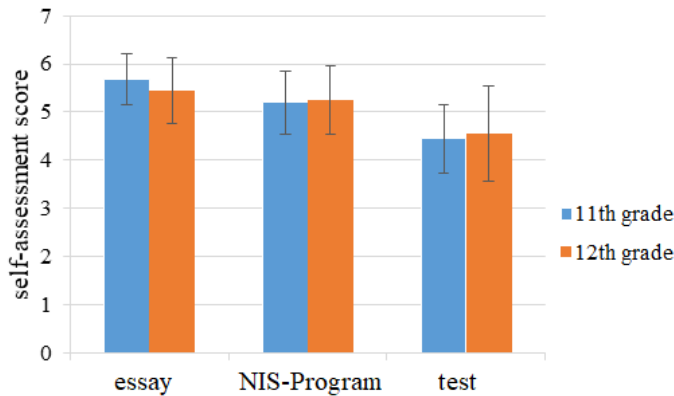


Figure 1. Results of filling out questionnaires, reflecting the attitude of students to tasks

was some difference in the success of responses to different tasks. The average result of the test evaluation among students of the 11th grade was 25.05 ± 2.52 , the graph of the distribution of scores had the form close to the Gaussian curve with the mode of 26 points. The average score for the NIS-Program tasks was 24.7 ± 2.20 . The differences with the control were not significant. Data analysis showed that the distribution of scores is shifted towards higher values. The mode was 28 points; 3 people got the highest score. Essay evaluation results: mean score 27.45 ± 1.99 , mode 25. At the same time, 4 people got the highest score. Differences in the results of assessment according to the NIS-Program significantly differed from the assessments on the other two tests ($p \leq 0.05$). Of course, these types of work reveal different competencies and cannot completely replace each other. However, there is an obvious tendency for integrative tasks involving associative links to update knowledge and help to attract factual material from related disciplines (Figure 2).

The results of an objective assessment showed that all the students of the senior classes completed all the proposed tasks at a sufficient and high level – the minimum score on a 30-point scale was 20. Such high academic performance indicates a high level of students' preparation and the correctness of didactic approaches. However, there

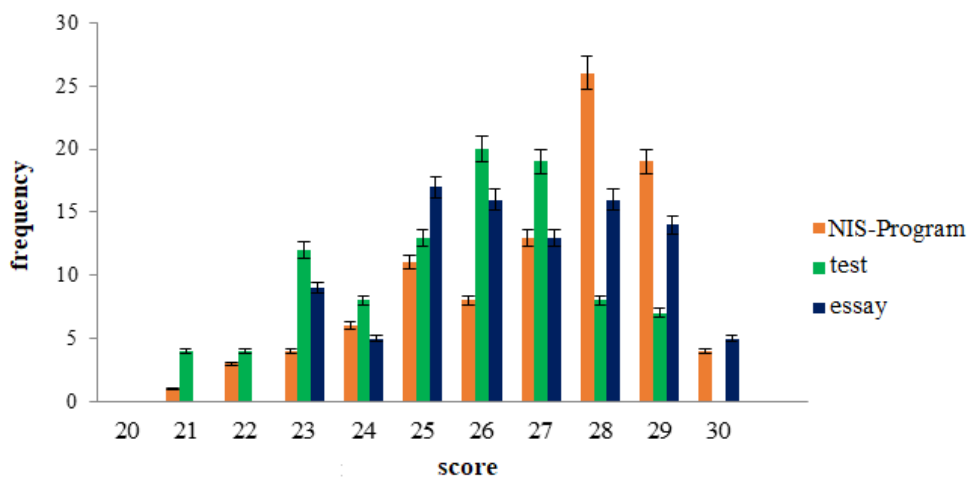


Figure 2. Results of assessing different types of tests for 11th grade students

An analysis of the assessment of 12th grade students showed a similar picture. The graph of the distribution of

results in all tests resembled a Gaussian curve. The average result of the test assessment among 12th grade students

was 24.95 ± 2.54 with the mode of 24 points. The average score for the NIS-Program tasks was 26.6 ± 2.09 . The distribution is shifted towards higher values, but the differences with the test control are not significant. The mode was 27 points. 4 people got the highest score. As you can see, the test results are comparable, despite the differences in the type of work and requirements. The

results of the essay evaluation showed that the distribution of points is the same as that in the 11th grade. The mean score was 25.35 ± 1.95 . The mode was 25; 2 people got the highest score. In the other two evaluation options, the highest score was 29 points (Figure 3).

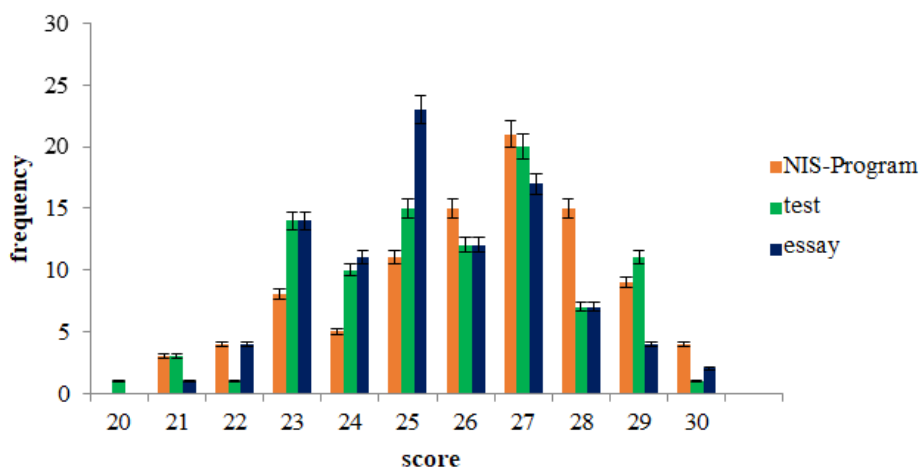


Figure 3. Results of assessing different types of tests for 12th grade students

Pairwise comparison of the results of each test in grades 11 and 12 showed no significant differences, which indicates the same ability of the students of senior classes under study to solve integrative problems. In both grades, there is a trend towards higher marks in the creative task, which testifies in favor of the effectiveness of using this knowledge assessment method.

When comparing the results of evaluating their own attitude to tasks and objective assessments, it was noted that students objectively evaluate their decision. When solving test problems, the average score was slightly lower, as the students assessed. As you can see, the solution of test tasks is somewhat more difficult, which is associated with the reliance of this task on the cognitive properties of memory. Integrative tasks, on the other hand, require the inclusion of associative and creative thinking, which can facilitate recalling certain facts. It must be understood that knowledge evaluation plays a huge role in the learning process and the same important role in the learning process as repetition. The combination and alternation of different forms of knowledge evaluation leads to a more detailed and holistic understanding of the subject and the formation of a wider range of students' competencies.

The type of test tasks and open tasks of the integral type are well known to students and are a routine form of knowledge evaluation in an educational institution. The essay form has not been used previously in the control of knowledge in a biology lesson and represents a new type of activity. Despite this, all students successfully completed this type of work and highly appreciated their own results. During the review of the essay, the following positive aspects of the work were noted, demonstrating an understanding of the integrity of the physical, chemical, biological aspects of the problem under study.

"All eukaryotic organisms have a cellular structure. Why

couldn't life develop like this without cellular organization? What molecules make up cellular organelles? What classes of substances do they belong to? How is this related to their functions?". Authors selected the most complete list of these that reveal the proposed topic and assessed the completeness of each student's answer, and then the relative number of students who gave these answers and examples. In their answers, the students pointed out the importance of the membrane in separating the inner space of the cell (100%).

At the same time, the main classes of chemical substances in the composition of the cell – lipids and proteins, the features of the chemical structure of molecules that ensure their function – polar structure of lipids, the amphoteric properties of proteins (100%) were indicated. A description of the physical properties of the membrane, providing its barrier and transport functions – polarity, fluidity (100%) is given. Differences between membranous and non-membranous organelles, features of their chemical composition and connection with functions (90%) were indicated. The functional difference of proteins with different tertiary and quaternary structures (83%), the features of their chemical and physical properties (75%) were characterized. The students explained why the cell is an open system, the concept of metabolism and energy (95%).

Colonial organisms were mentioned as transitional forms, comprising many non-specialized cells, which limits the development of organisms (69%). Examples were given of how the environment determines the features of cell specialization, for example: epithelial cells acquire polarity due to the boundary position in two environments (50%), blood cells acquire a streamlined multidimensional shape due to circulation in a liquid homogeneous medium (67%), muscle cells lose cell boundaries due to close contact and synchronous work (55%). Students learned the basic ideas of cell theory, understanding the unity of the

structure of cellular organisms and the principles of development of multicellular systems.

Students of 12th grade were faced with the following task: "Bioorganic molecules – how life originated on their basis? What levels of organization of living beings do you know? What factors contributed to the complexity of living systems and the emergence of new levels of organization?". Authors selected the most complete list of theses that reveal the proposed topic, and assessed the completeness of each student's answer, and then the relative number of students who gave this example. The students listed and gave characteristics of the main classes of bioorganic molecules (100%), described the chemical bonds that form the primary, secondary and tertiary structure of various molecules (93%). They described the experiments performed by Miller and Urey to substantiate the theory of Oparin and Haldane (90%). Examples of chemical reactions for the synthesis of amines and amino acids from inorganic components – carbon dioxide, water, ammonia (76%) were given.

The physical factors necessary for the occurrence of such reactions were indicated (79%). Modern ideas about the atmosphere of the ancient earth, in which life originated (73%), and the structure of nucleic acids (95%) were described. They explained the possibility of self-copying of nucleic acid molecules according to the principle of complementarity and the role of this process in the origin of life – reproduction, the formation of diversity (74%). In response to this question, the material from the topic "Genetics, the genetic code" was updated. Examples were given of how conditions can affect the diversity of life: the emergence of autotrophic and heterotrophic nutrition – on the example of bacteria (64%), the formation of multicellularity as a way to save energy – on the example of colonial algae (67%), the appearance of chemosynthetic bacteria and extremophiles in thermal springs, volcanoes, methane and sulfur sources (58%), the emergence of multicellularity through the specialization of cells to various functions (79%).

The answers demonstrated in-depth knowledge of the subject, an understanding of the processes of the origin of life as a single physical and chemical process, continuous morphogenesis occurring under the pressure of environmental conditions. The examples demonstrated a vast naturalistic erudition. In the course of answering open questions, the students demonstrated such qualities as in-depth knowledge of the material of the topic covered, the ability to find a connection between this material and previously covered topics, as well as related disciplines – chemistry and physics.

The students demonstrated the ability to think deductively – explaining natural phenomena on the basis of the theoretical material covered, and inductively – choosing examples illustrating theoretical positions. Thus, all students demonstrated knowledge of the fundamental material of the curriculum, 100% of answered questions related to the main material of the topic. Sample answers demonstrate in-depth understanding of the material of both the topic covered and related disciplines. Most of the students correctly established interdisciplinary connections, finding connections between various natural processes.

In general, it can be said that the expected requirements formulated at the beginning of the experiment were largely met by the majority of students. A special role should be given to the role of mind maps in the process of compiling an answer. Mind maps are a universal tool for processing, systematization and brief presentation of any material. Therefore, their significant supporting role is beyond doubt. Their dichotomous hierarchical structure is the best way to display logical interdisciplinary connections. All participants in the experiment succeeded in their compilation and, during the subsequent discussion, noted that mind maps helped them focus on the material and develop a plan for its presentation. The very form of an open question – an essay as another way of interdisciplinary integration – should also be noted, since the need for a consistent, coherent and logical presentation of the material requires the actualization of the verbal-logical style of thinking and the activation of language skills.

Discussion

As discussed above, the Nazarbayev Intellectual Schools Educational Program (NIS-Program) is being developed taking into account the experience of international integrative education programs and includes authors' integrated tasks according to the A-level standard. In general, integration in the educational process involves the sharing of material and the generalization of knowledge from different sections and disciplines [4]. This paper contributes to the understanding of the value and interchangeability of different types of knowledge evaluation, and their functions in the educational process. The experience of international programs (STEAM, PISA) following its peer review and selection was used to develop methods and techniques for integrative learning [15]. The tasks used by the authors in the course of this research demonstrated a high level of correct answers and the development of appropriate skills in high school students. Education at the Nazarbayev Intellectual Schools in chemistry and biology takes into account these programs, has its own experience of testing them [21], and demonstrates high rates of solving problems of this type.

The problem of integrative forms of work in the natural sciences has been widely studied both by scientists from the Commonwealth of Independent States [10; 13; 22] and researchers from other countries [7-9]. In this paper, the authors compared various forms of knowledge evaluation and proposed a method for writing an essay and compiling a mind map as a way to systematize and integrate interdisciplinary connections. K.Yu. Slyusarenko and I.L. Shishkina [11], referring to the criteria of V. S. Avanesov, propose the development of integrative tests that combine materials from biology with geography, history, and chemistry. This paper emphasizes the importance of observing the following principles when developing integrative tasks:

1. Compliance with the goals of testing (in this research – thematic control of knowledge, skills and abilities on the topic covered).

2. The significance of the material submitted for verification, i.e., the most key, connecting facts. In this case, authors submitted for verification the most

fundamental issues – the unity of the cellular, chemical composition and the development of living systems.

3. The relationship between content and form. This includes interdisciplinary connections that authors used – with chemistry, physics, language.

4. Substantial correctness of assignments, scientific reliability of facts and adherence to the currently dominant scientific theories were ensured by compliance with the teaching course.

5. Representativeness of the content of the subject in the test task. According to the authors of this paper, the form of open questions, an essay requires maximum disclosure of the material of the topic under study as well as related ones. The same function is performed by an extensive test task.

6. Compliance of the content of the task with the level of modern science is ensured by the constant improvement of the curriculum and the congruence of tasks.

7. Complexity and balance of the content of tasks. To meet this criterion, the tasks included the maximum number of subtopics and examples for the most extensive presentation of knowledge by students.

8. Content system. The system of integrative knowledge evaluation is based on this principle. It is expressed in the establishment of relationships between different areas of knowledge.

9. Content variability. It is expressed in the presence of tasks of different complexity. In the case of open tasks – different levels of presentation complexity: factual, analytical, synthetic, generalizing examples. Confirmation of the compliance of the tasks selected in the paper with this parameter is the normal distribution of scores obtained as a result of evaluation, with a median in the high-level score area.

The types of work used in the course of this research meet all the criteria for integrative tasks. From the results obtained in the course of this experiment, it follows that the integrative tasks developed within the framework of the NIS-Program make it possible to identify the most key facts of the thematic material on the topics covered. They introduce students to the provisions of modern scientific theories and allow them to provide a level of education that meets international standards of education and science. A high level of correct answers to the establishment of intersubject relationships between biology, chemistry and physics indicates compliance with the criterion of content consistency. The presence of tasks of increasing complexity ensures the variability of the content [23]. Thanks to this criterion, the tasks not only actualize the associative connections of the respondents, but also are of interest to them in the process of performance, which is reflected in the answers to the questions of the descriptors.

The issue of the formation of a natural science world outlook remains open in modern scientific discussion, which is especially important in the light of the progressive development of biochemical, biophysical, and molecular methods for studying the world around us. The natural science world outlook is a realistic picture that reflects the current level of understanding of the structure of nature and man. Today, the following criteria for a formed natural science world outlook are proposed:

– the presence of high motivation to study the natural sciences;

– knowledge of natural science terms, the essence of concepts and laws, and the ability to explain natural phenomena on their basis;

– knowledge of research methods and the ability to apply them to carry out educational and research work;

– developed ability to reflect, assess own level of natural science knowledge and understanding, the ability to find own mistakes [14].

During the thematic evaluation, the level of theoretical knowledge and the ability to use it to describe natural phenomena were determined. The ability to reflect is tested and practiced in the course of answering questions on self-assessment descriptors. The high correspondence between these two methods testified to the high development of reflection skills. Motivational and activity-practical aspects are implemented in the course of preparing classes and performing practical and laboratory work, which together contribute to the formation of a holistic natural science perception.

Conclusions

Three types of control tasks are studied in the paper, examining the level of mastering the educational topics of the "Biology" course. The research was conducted by way of a stating experiment among students of grades 11-12 of the Nazarbayev Intellectual Schools in chemistry and biology in the city of Kyzylorda. The following types of tasks were studied: a test task with a narrow focus, integrative tasks developed by the authors according to the NIS-Program, and an essay on a given topic with a mind map. Mind maps served as an additional tool for systematizing and updating knowledge. All authors' tasks met the requirements for integrative tasks. It was demonstrated that all tasks were completed by students at a high and sufficient level, no low-level scores were received.

In grades 11 and 12, tasks from the collection of developed NIS-Program integrated tasks were performed at the same level as the standard test tasks of a narrow focus, which indicates the same adaptation to these forms of knowledge evaluation. The distribution of students' answers to all questions corresponds to the Gaussian distribution, which indicates the representativeness of the test results. Estimates for all types of work were in the range of 20-30 points. The mode of mean scores for all tests was in the range of 24-28 points. Significant differences were found in the performance of tasks of the integrative type according to the NIS-Program in comparison with standard test tasks. Essay writing results were also higher compared to the evaluation of standard test items, but the differences were not statistically significant. This may be due to the actualizing function of tasks, the involvement of associative links when performing integrative and creative tasks.

The results of students' self-assessment of test performance reflected an objective picture of the distribution of scores, which indicates the development of scientific self-reflection and the objectivity of students' self-assessment. The results of self-assessment by descriptors of essays and open questions were significantly higher than those when solving test tasks. In the course of answering open questions, the students demonstrated such qualities as in-depth knowledge of the material of the topic

covered, the ability to find a connection between this material and previously covered topics, as well as related disciplines – chemistry and physics. Respondents demonstrated the ability to think deductively – explaining natural phenomena on the basis of the theoretical material covered, and inductively – choosing examples illustrating theoretical positions.

During the analysis of essays and answers to integrative tasks, the following signs of a high formation of natural science thinking were identified: motivation to study the natural sciences, knowledge of natural science terms, the essence of concepts and laws and the ability to explain natural phenomena based on them, a developed ability to reflect, assess one's own level natural science knowledge, the ability to find own mistakes. Thus, based on the experiment and the analyzed scientific sources, it can be recommended the integrative tasks developed by the authors using the case-study method that correspond to the A-level standard. It is also possible to alternate different types of knowledge evaluation in the practice of teaching biology. The developed methods show the effectiveness of the methodology authors have chosen in shaping the natural science thinking of students of grades 11-12.

Various types of evaluation are aimed at developing versatile skills and train the cognitive flexibility of high school students. Solving problems of an integrative nature, in particular, writing essays and compiling mind maps, can update and develop natural science thinking in high school students. The ability to keep in memory for a long time and apply the knowledge gained in the future is important for the formation of a natural science world outlook. Therefore, further research should be devoted to the evaluation of residual knowledge by the methods described, which is usually carried out during the final annual evaluation. This research may be useful for biology teachers to expand approaches to knowledge evaluation within the framework of integrative learning, as well as researchers and developers of such methods.

Acknowledgements

N/A.

Conflict of Interest

N/A.

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Як завдання інтегративного характеру сприяють реалізації світоглядних ідей учнів старших класів у предметі біології

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Анотація

Актуальність. Інтеграція різних галузей знань є важливою тенденцією в сучасній освіті, особливо в природничих науках. У Назарбаєвських інтелектуальних школах формування цілісного наукового світогляду та розвиток здатності учнів до синтезу інформації є ключовими освітніми завданнями.

Мета. Це дослідження має на меті порівняти ефективність трьох методів оцінювання знань у сприянні формуванню цілісного природничого світогляду серед старшокласників. Воно спрямоване на визначення, які методи оцінювання найбільш ефективно покращують когнітивні процеси.

Методологія. У дослідженні взяли участь 95 учнів 11 і 12 класів Назарбаєвських інтелектуальних шкіл в Кизилорді, з акцентом на хімію та біологію. Було проведено педагогічний експеримент, де учнів оцінювали за трьома методами: стандартні тести, інтегровані завдання відповідно до Освітньої програми Назарбаєвських інтелектуальних шкіл, есе, що вимагали міждисциплінарних знань.

Результати. Дослідження показало, що учні обох класів успішно виконали всі типи завдань, але їхні результати були помітно вищими при виконанні інтегрованих завдань та написанні есе порівняно зі стандартними тестами. Статистичний аналіз підтвердив значні відмінності між методами, що свідчить про те, що інтегровані завдання та есе краще сприяють активації когнітивних процесів та асоціативного мислення учнів. Відгуки учнів показали перевагу інтегративних завдань у відкритому форматі над традиційним тестуванням.

Висновки. Висновки свідчать про те, що інтегровані завдання та есе, які вимагають від учнів використання міждисциплінарних знань, є більш ефективними у формуванні цілісного природничого світогляду та підвищенні когнітивної активності, ніж традиційні методи тестування. Ці методи покращують запам'ятовування знань та сприяють глибшому розумінню шляхом зв'язування концепцій з різних наукових дисциплін. Дослідження рекомендує впровадження цих інтегративних підходів у викладання біології та інших природничих наук. Майбутні дослідження мають зосередитись на подальшому вдосконаленні цих методів для зміцнення міждисциплінарних зв'язків та підтримки розвитку просунутого природничого мислення у старшокласників.

Ключові слова: інтегративні завдання; природнича освіта; міждисциплінарні зв'язки; компетентності учнів; світогляд.