

## THE PRIORITIES AND THE MAIN BRANCHES IN THE IMPROVEMENT OF THE NATURAL SCIENCES EDUCATION AT THE UKRAINIAN SECONDARY SCHOOL

**Rezumat.** În articol se analizează problema formării competențelor elevilor în cadrul studierii ariei „Științe ale Naturii” (fizica, chimia, biologia) în școlile din Ucraina. Este prezentată fundamentarea științifică și tehnologică a formării competenței de cunoaștere științifică a lumii în cadrul studierii fizicii, chimiei și biologiei. Sunt propuse unele soluții privind îmbunătățirea studierii științelor ale naturii în școală.

**Cuvinte-cheie:** priorități, direcții, educație, științe ale naturii, competențe, perfecționare, școală.

The updated educational strategy in Ukraine predetermines the qualitative modernization of the structure and the content of the comprehensive secondary and higher education, the improvement of the organizational structure, the methods and the forms of education. The important step for meeting the world education standards became the adoption of the Law of Ukraine „On Higher Education” in 2014. This legislative document formalizes the branches of the further development of the higher education system as well as their implementation tools in law. The design of the main provisions of the law on education, which is to determine the comprehensive secondary education concepts, is being completed. A distinctive feature of the modern educational processes in Ukraine is drawing the attention of scientists, analysts, experts, representatives of public organizations to the development of the education strategy. The Draft of the Concept of education development in Ukraine for 2015-2025, developed by an expert group under the Ministry of Education and Science is being publicly discussed. It analyzes the main reasons for the crisis phenomena in the education system; they are the following: the lack of funding; the run-out of the material and technical base; the decline of the teacher’s social status; the excessive centralization management of the comprehensive educational institutions; the imperfection of the mechanisms of ensuring the equal access to the education quality; the

lack of a clear system in the updating of the education content; the imperfect system of the education quality monitoring.

An important branch in the transformation of the comprehensive secondary education was defined to be the focus on preparing the pupils in natural science, in particular, in its practical part by means of the qualitative renovation of laboratory facilities, equipment in the physics, chemistry, biology, geography classes, modern complexes for the computer support learning. The necessity and the timeliness of paying attention to this problem is confirmed by the results of an international comparative study of the quality of the mathematical and natural sciences education TIMSS, in which Ukraine took part in 2011. The analysis of the results of the large-scale international project provides an opportunity not only to monitor the academic achievement of students in natural sciences and to compare them with the successes of their peers from other countries, but also to identify problematic issues and to make the grounded decisions on the modernization of the education content, the increase of the quality level of the natural sciences education.

In the studies of TIMSS, Ukraine was represented by 3378 pupils of the eighth grade from 148 secondary schools. The schools were chosen by probability method from the general list of the state educational institutions. The basis for the monitoring system

comprised the tests of knowledge in natural sciences, the questionnaires for pupils, teachers, school administrators, education experts. The evaluation of the study results was carried out on a 1,000-point scale. Therefore, the average academic performance in making assignments by pupils was determined as 485 points for Ukraine, while higher indexes were 567 points (Singapore), 561 points (China), and 554 points (Japan).

In spite of the fact that the results cannot be considered as perfect, their analysis allows to find out the objective reasons for the current problems in the educational sector „Natural Studies”. Among the students who participated in the evaluation, only 6% showed the highest level of education in the natural sciences, the knowledge of 23% of pupils were assessed as a high one, and 35% of them showed the average level of awareness. The low level of knowledge was demonstrated by 24% of pupils, and fragmentary knowledge was obtained by 12% of them (it is less than the international standard for the low-level training in natural sciences). In this indicator, the leaders are Singapore (69%), Finland (53%).

In accordance with the international standards, the high level of knowledge is demonstrated by the pupils who can apply their knowledge in order to explain the natural processes; they are able to compare the features of living organisms, to understand the scientific research principles, the factors affecting the people's health. The test in the natural sciences included 35% of the tasks in biology; 20% in chemistry, 25% in physics and 20% in geography. In correspondence with the type of learning and cognitive activity, the tasks were divided into three groups: the task –the knowledge (35%), the problem – the application (35%), the problem – the specification (30%). Ukrainian pupils have demonstrated the highest average score for the tasks focused on the use of knowledge in standard situations, and the lowest one in the knowledge application [2].

The analysis of the results of monitoring the pupils' educational achievements in natural sciences TIMSS as well as the research of the Ukrainian scientists

on this issue demonstrate that the peculiarity of the homeland natural sciences education is its focus on the formation of reproductive knowledge. In the theoretical training, the Ukrainian schools are not inferior, and in some parameters, they even surpass the foreign educational institutions. However, the confident representation of the pieces of knowledge which were acquired in the process of studying the natural sciences does not guarantee the practical usage of the knowledge and skills for the solution of the practical tasks. Considerable difficulties are faced by the pupils of secondary schools when they receive the tasks that require comparison and classification, formulation of value judgments, conscious understanding of nature as a whole system.

As a rule, theorized knowledge does not coincide with any real-life situations. The skills to fulfil the academic tasks in accordance with the certain algorithms are useful for the academic tasks solutions, but do not provide a creative approach to the solution of the non-standard situations, an active search educational and cognitive activity, a maximum use of available information and reference resources (additional conditions, descriptive graphs, tables, charts, drawings). Such component of educational activity as independent planning and decision making for the school educational experiment, which is extremely important for the secondary institution, was insufficiently implemented. Therefore, there is an objective necessity to reorient it from the knowledge paradigm, to the paradigm of the competence-based education which results in the formation of the subject competences in Biology, Chemistry, Geography, Physics, and Astronomy as well the Natural Sciences competence as a key one [4].

The ways of the solution of this problem are outlined in the State standard of the basic and the full comprehensive secondary education (2011). This legislative document is based on the principles of the personality-oriented, competence, and activity-based approaches, implemented in the educational areas and represented in the resultative components of the basic and the full compulsory secondary education.

The principle key competencies determined by the State Standard can be considered to be the most topical for the natural sciences education. In particular, they include the academic competence, mathematical and basic competences in the area of natural sciences and technology, information and communication, health-preservation competences [5].

The paradigm of the competence-oriented learning is a methodological basis for the Concept of profession-oriented learning, developed by the scholars of the Institute of Pedagogy of the NAES of Ukraine (2014). The principles of the competence-based, personality-oriented learning and activity-based education defined the tasks of the profession-oriented school, namely, the ensuring of the comprehensive secondary education for pupils, the promotion of the life and the professional self-determination of the schoolchildren, the opportunities for the design of their own educational trajectory, the task-oriented preparation of pupils for the successful continuation of studying at the further educational levels in certain areas, the creation of the conditions for studying some professions in order to meet the requirements of the labour market. The content of the profession-oriented education includes the invariable and the variative components. The invariant content component is present in the basic school subjects (the Ukrainian Language, Literature, Foreign Language, History, Social Studies, Mathematics, Natural Studies, Technologies, Art, Physical Training, and Health-Preservation).

The basic subjects can be studied at the level defined in the state standards (the standard level and the basic level) or at the in-depth studying level (at the profession-oriented one). At the standard level, the basic academic subjects can be studied as the integrated courses or as the courses designed in accordance with the module principle (each module represents the content of the corresponding education component). At the profession-oriented level, the basic subjects can be provided in the form of the profession-oriented ones. Therefore, for instance, at the standard level, the educational area "Natural Studies" is represented by

the subject "Natural Studies" which includes physical, biological, chemical, geographical, and astronomical components. The profession-oriented education level is ensured by the following profession-oriented subjects: Physics, Biology, Chemistry, Geography, and Astronomy [6].

A more complete fulfilment of the tasks of the profession-oriented education is ensured by the variative content component that is considered to be the primary means of education individualization. This component is formed by the comprehensive educational institutions independently and makes it possible to direct the learning process to meet the pupils' individual educational needs. The variable component determines the content of the profession-oriented subjects and elective courses (special and additional courses). On the basis of the combination of invariant and variable components, comprehensive educational institutions form the professional orientation of learning. The content of each training profile is implemented in the basic academic subjects which are studied at the standard level, the profession-oriented subjects (there are usually two or three of them), and elective courses. For example, for philological basic subjects will be the following: History, Social Studies, Mathematics, Natural Sciences (Astronomy, Biology, Geography, Physical and Chemical Components), Technology, Art, Physical Training and Health; the profession-oriented subjects include Language and Literature; elective courses are Rhetoric and Culture of Speech. For the physical and mathematical structure, basic subjects will be the Ukrainian Language, Literature, Foreign Language, History, Social Science, Natural Science (Biology, Geographical and Chemical Components), Technology, Art, Physical Education and Health; the profession-oriented subjects include Mathematics, Physics, and Astronomy; elective courses comprise Mathematical Modelling, Physics of Wildlife. For both examples, the basic subject is science. However, the content of this integrated subject for the philological professional orientation includes all education components whereas for the Physics and Mathematics

profile, physical and astronomical components, which will be studied as a separate profile subjects, will be removed from its content. In case of removing the integrated academic subjects as the content component, the extra academic hours will be present; they can be spent for the optional courses.

An important role in the formation of the pupils' natural science competence at the profession-oriented school is played, namely, by the variation component. Optional courses deepen and expand the academic content of this very profile (the most important sections of both specialized and non-core subjects). The main purposes of the specific courses are identified to be the improvement of the practice-oriented focus of knowledge; getting acquainted with the new branches of the natural science knowledge, the scientific fundamentals of production and modern environment-protective as well as reconstructive technologies; the formation of an integrated natural sciences, social and humanitarian world outlook based on the knowledge integration and interdisciplinary generalizations; ensuring of the high school pupils' professional training.

Optional courses contribute the maximum satisfaction of the individual cognitive interests and educational needs of the profession-oriented school pupils that cannot be directly related to the selected profile training. For example, students who master the natural sciences can improve their knowledge in the Ukrainian or Foreign Language, Philosophy, and Psychology as the optional courses.

The successful implementation of the specialized education, the fulfilment of the tasks of science education is possible under the fundamental changes in the approaches to the material and technical provision of the profession-oriented education. Modern profession-oriented natural science education is impossible without modern laboratory facilities as well as information and communication technologies. A system of the didactic provision of the profession-oriented education requires to be developed; it includes the curriculum of the basic academic subjects for the standard and the profes-

sion-oriented levels; the methodological support of academic subjects and the diversity of special courses (an educational program, a handbook for students and the methodological guidelines for teachers); the educative and methodological support of the optional courses; the system of the distance learning of the core subjects and the elective courses; methods and technologies of teaching natural sciences. The problem of training the natural sciences teachers who are motivated to achieve the goals of the specialized education appears to be topical. Besides, there is a need to establish a system of training the high school teachers of natural sciences; the reason for it is the fact that such integrated multi-component subject is a basis for all profiles.

In 2014, the National Academy of Educational Sciences of Ukraine conducted a systematic analysis of the content of the comprehensive secondary education. It demonstrated the necessity of the specification of subject competences in natural subjects to determine their contribution in the formation of the natural scientific competence, the interdisciplinary coordination of training programs in order to create a coherent world outlook (at a secondary school); the feasibility of a clear definition of natural science competency; the development of its structure and content, the addition of the tasks in this area by means of the formation of the students' natural-scientific world outlook, the concretization of the state requirements for the level of the comprehensive secondary education of pupils, the determination of the principal components of the educational area "Natural Studies" (the high school) [3, p. 52, 74].

Since the formation and the development of natural science competency is being carried out during the implementation of the education content at all levels as an important task is to implement the competency approach in the courses for both senior and primary schools. In 2015, the revision of curricula for primary schools for the purpose of making them easier and achieving the objectives of the profession-oriented education. The programs on Astronomy, Biology, Physics, Chemistry, and Geography made the

competence-based approach in the implementation of the training content more effective, primarily by means of the competence-orientation of the system requirements for the levels of students' achievements.

Our researches allow to observe the natural sciences competence of a comprehensive educational institution graduate as an integrated personal characteristics which ensures the readiness of a young person to communicate with nature and social environment successfully, to make a conscious choice of a future professional activity oriented at the solution of the practical problems of the scientific and productive activity the basis of which are the phenomena and the processes in nature. The basis for the formation of natural science competencies comprises subject competences which include the corresponding knowledge, skills, experience of the creative activities in the area of natural sciences.

Natural science competence includes the ability of the productive activity based on modern concepts of the complementarity of a man and nature; it provides an opportunity to investigate the natural phenomena and the processes of nature with adequate means systematically, to use cognitive activity algorithms, measurements, models which allow to solve, firstly, academic problems, and then, scientific and industrial problems with different methods; to interact with the environment harmoniously, to make environmentally-based decisions on environmental management, to design and to implement the energy and environmentally friendly technologies [1].

The main directions in the formation of natural science competencies can be outlined as follows:

1. the content of the educational area of the Natural Science in the State standard of basic and higher secondary education, which predetermines the basic content of the natural line of modern education in the secondary school requires to be deeply improved, in particular, in the branch of ensuring the formation of a strategic field of educational goals and the development of personal, individual-typological features of pupils that determine their future productive activities based on modern concepts of complementarity of a man and nature as well their system skills to investigate natural phenomena and processes by his adequate means;
2. the consistent implementation of the competence-based approach should be ensured in the process of the development of training programs on the subjects of the natural cycle for the secondary school, in particularly, ensuring an applied orientation of the content, its focus on the formulation of educational tasks which require students' systematic skills in the creative activity which at the same time are formed as a result of the scientific and theoretical understanding of the results of analysis of the natural phenomena (at the appropriate level, which is peculiar for a certain education and age group). The improvement of the structure and the content of school subjects, ensuring the formation of the students' natural-scientific picture of the world should be determined by the transition from the conceptual content line "people - the consumer of natural resources", which was characteristic of the technology-related society to a person - an integral part of an organic nature", as a modern concept of interaction between a man and nature. In this context, system requirements for the level of the development of the educational competencies of students require the further improvement and standardization;
3. taking into consideration the fact that the formation and the development of natural science competence is provided by means of the school physical, chemical, biological experiment, it is advisable to implement modern methods and techniques of a school physical experiment aimed at creating conditions for the didactic mastering of the important ways to practice and the possibilities for the generalization of the results in the acquirement of the academic knowledge. One of the directions is the didactic substantiation of the formation and the use of modern subject classrooms in the comprehensive school educational process.

4. one of the leading areas in the implementation of the competence-based approach in a secondary school is to create a new generation of textbooks and manuals on its basis. An important requirement of the modern textbook methodological apparatus should be the focus of the content and the academic tasks on the formation of the integrated practical skills training in making creative solutions of the problems and the challenges associated with the arrangement of a harmonious relationship with nature and society;
5. the didactic problem of the development of the sample measurements of the students' educational achievements in natural subjects on the basis of the competence-based approach requires the in-depth researches. The topical theoretical and technological aspects of the formation of the structure, the content of the sample complex tasks aimed at identifying the natural science competence through the subject competence formation; the design of the bank of the competence-oriented tasks by means of which the students are given an opportunity to assess the results of the school science education;
6. under the conditions of informatization of all public life areas, science and industry information technologies play an important role in the development of students' information and communication competence. It is noteworthy to pay attention to the didactic justification for the use of a personal computer as a means of self-development and self-education.

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