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TÍTULO: El potencial de las ciencias naturales para desarrollar la cosmovisión científica entre los estudiantes del último año de secundaria.

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RESUMEN: El artículo revisa el potencial de la astronomía, la física, la química, la geografía y la biología para transmitir la cosmovisión científica a los estudiantes de secundaria de la escuela de educación general. Los autores presentan un diseño original del proceso educativo centrado en facilitar la comprensión del material educativo dedicado a la formación gradual de la cosmovisión, la descripción de sus componentes estructurales, y la exploración de su valor científico y práctico. La adquisición de este conocimiento al final de la escuela y las acciones correspondientes para su aplicación en situaciones educativas y en la vida cotidiana es un indicador de la cultura desarrollada de la cognición.

PALABRAS CLAVES: colegio de enseñanza general, enseñanza de asignaturas, cuadro científico del mundo, asignaturas del ciclo natural científico, alumnos de secundaria.

TITLE: Potential of Natural Sciences for developing the Scientific Worldview among High School Seniors.

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ABSTRACT: The paper reviews the potential of astronomy, physics, chemistry, geography and biology for conveying the scientific worldview to the high school senior students at general education school. The authors present an original design of the educational process focused on facilitating comprehension of the educational material devoted to the gradual formation of the worldview, description of its structural components, exploration of its scientific and practical value. Acquisition of this knowledge by the end of school and the corresponding actions for its application in educational situations and everyday life is an indicator of the developed culture of cognition.

KEY WORDS: general education school, subject training, scientific worldview, natural sciences, high school seniors.

INTRODUCTION.

In order to ensure the progress of humanity towards the continuous maintenance of the natural state of the surrounding world, optimal environmental condition and good human health, it is essential that the younger generations have a holistic and generalized view of the Earth, its organization and functioning (Bell et al., 2019; Chase, 2013; Tasić, 2014). For this reason, appropriate pedagogical tools are now being sought for and implemented throughout the world, especially with regard to general education, which is designed to ensure the literacy of the majority of the population in order

to achieve the pursued common goal. One of such tools is the targeted formation of the fundamental scientific worldview among schoolchildren (Andreeva et al., 2013; Kamal, 2007; Usova, 2011; Prepis, 2018; Teremov, 2013; Yakunchev & Semenova, 2016).

A clear idea of the world as a sum of knowledge about the nature, its systemically important properties and laws of continued existence and the reasonable use of such knowledge in practical activities today have become an important attribute of an individual belonging to the post-industrial society. Therefore, when such a clear understanding exists, it may be considered as one of the indicators of a new culture of interactions between the nature and a human, which manifests itself in the rejection of the discrete perception of inanimate objects and living creatures, the mandatory observance of the natural interrelations between them, and, most importantly, the sensible application of the obtained natural science knowledge in the performance of biospherically compatible and culture-congruent actions with respect to the nature on Earth, the environment and public health.

DEVELOPMENT.

Literature Review.

The study of literature has shown that the problem consisting in the development of a scientific worldview among schoolchildren has received certain attention. The evidence may be found in the works of Russian and foreign authors.

The best way to represent the results of their analysis is to distinguish two dimensions. The first one deals with the discussion of essence, structure and characteristics of the pictures of the world through different levels of their cognition, and the second one is concerned with the discussion of potential of academic subjects for the development of a scientific worldview of schoolchildren. In its structure, we were especially interested in the works of such researchers as M.K. Gusejkhanov

(Gusejhanov & Radzhabov, 2012), A.A. Namir (2010), V.S. Danilova (Danilova & Kozhevnikov, 2008a, 2008b), N.N. Kozhevnikov (Danilova & Kozhevnikov, 2009), N.V. Klyagin (2012), J. Schulte (1988), M. Marsonet (2016), E.J. Dijksterhuis (1971). With reliance on them, we were able to clarify the meaning of such concepts as "scientific worldview", "natural-science worldview", and, most importantly, to distinguish their components and provide brief descriptions thereof. Otherwise, it would be difficult to determine the educational material for high school students necessary for shaping their idea of the scientific worldview.

In the structure of the second dimension, particular importance was attached to the studies by teachers on the need for schoolchildren to assimilate the knowledge about the pictures of the world. The importance of such approach with some recommendations to teachers in certain subject areas has been stated in the works of B.D. Komisarov (1991), A.M. Kondakov (Kondakov & Kozlov, 2009), A.V. Usova (2005), A.V. Teremov (2007), S.M. Pohlebaev (2002), A. Prepis (2018), K. Kampourakis (2018), Kamal Abu Safia (2007). The content of these works was important for us in terms of our search for a scheme for the development of the scientific worldview among the high school seniors and filling its elements with the appropriate content. Unfortunately, in the analyzed sources we have not found a holistic mechanism to shape separate elements of the scientific worldview and to integrate those into the final stage of general education of high school students.

Research methodological framework.

The materials were the results of theoretical analysis of philosophical, natural science and pedagogical literature, which allowed to describe such concepts as "scientific worldview", "natural-science worldview", and to determine their elements and meaning in the present-day general education.

The materials of the research also included the results of verification of the recommendations developed by us for the successful assimilation of knowledge about the scientific worldview by high school students.

The research was carried out based on the theoretical and empirical methods, in particular, the analysis of literature, generalization and systematization of the obtained data, conversations with high school students in relation to the expression of their acquired knowledge about the world picture, its scientific and practical values.

The objective of this paper is to reveal the potential of the natural sciences to shape the idea of the scientific worldview among the high school students. The tasks were as follows: 1) Reveal the essence of priority concepts about the scientific worldview; 2) Test the procedure developed by the authors for shaping the scientific worldview among the high school seniors based on the defined concepts.

Findings and discussion.

Addressing the first task of this research, we would like to note that for the successful formation of a natural science worldview among schoolchildren it is possible to benefit from the variety of school subjects. Preference should be given to those that relate to the study of nature - astronomy, physics, chemistry, biology and geography. To realize their potential in general education, the essence of certain concepts should be defined. Such concepts are "the general worldview", "the unscientific worldview", "the scientific worldview" and "the natural-science worldview". The first one, “the general worldview", has evolved over a long period of time. However, its generalized expression appeared in natural science and philosophy only at the end of the 19th century, and a full scientific analysis has begun since 1960s.

As concerns the school education, we define this concept as a holistic image of reality, which has developed historically within the frontiers of human knowledge and is reflected in a relatively systematic knowledge of nature, society and technology, accumulated experience of people for use in different spheres of practice. Since the human life is multifaceted, with the accumulation of new knowledge in the depths of the general worldview, more specific views have emerged and evolved. With regard to the education of schoolchildren, we distinguish a number of their exponents, presented in a generalized form in Figure 1 (produced by the authors).

<table>
<tr><td colspan="4">GENERAL WORLDVIEW
A specific form of relatively systematized knowledge about nature, man, society and technology, accumulated through people's historical experience for its application in different spheres of life</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="4">UNSCIENTIFIC WORLDVIEW (RELIGIOUS)
A body of knowledge that has not been proven or substantiated by fundamental science</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="4">SCIENTIFIC WORLDVIEW
The generalized and systematized knowledge about nature, man, society and technology, proven and justified by fundamental sciences</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>Natural-science worldview
– The knowledge about nature, its laws and their use in practice</td><td>Social worldview
- The knowledge about society and the phenomena occurring in the human world</td><td>Humanitarian worldview
– The knowledge about the place of a human in the society and the human culture</td><td>Technological worldview
- The knowledge about the technical devices, technologies and their applications</td></tr>
</table>

Figure 1. Components of the Worldview (Source: authors).

The unscientific worldview is a special field of knowledge and human practice that is based on faith and as such is subjective. The scientific worldview is based on the most common properties and laws of nature, society and mankind, revealed by scientific methods of cognition and as such is objective. Due to this, it reveals connections between the real world of people and scientific knowledge, which is constantly replenished. It happens because it has in its composition the

complementary scientific pictures pertaining to different spheres - natural science (nature), humanitarian (human), social (society) and technological (machinery and technology).

For science and practical activity of a human, it is essential to have a good idea of the natural science component of the scientific worldview. It is understood as a specific form of expression of knowledge about nature, its properties, proven and substantiated by fundamental science and necessary for use in different spheres of human life. Its general sense is represented in Figure 2 (Yakunchev & Semenova, 2018).

Addressing the second task of this research, we would like to focus on the procedure of creating an idea about a particular component of the scientific worldview through the use of certain subjects studied by senior students at the Russian high schools. They approach the final stage of education with a sufficient store of empirical knowledge, which needs to be generalized.

With regard to astronomy, physics, chemistry, biology and geography, this is manifested in the integral expression of methods for studying the natural world, knowledge of it, ideas about the interrelations between different bodies, the transformation of substances and energy as a result of biogenic and anthropogenic phenomena, environmental changes, inanimate objects and living creatures, human health and lifestyle under the influence of various factors.

As has been shown by the pedagogical practice of teachers using the proposed developments in the area of interest to us, the essence of the natural-science worldview is better conveyed to the high school students under the developed scheme.

Natural-science worldview – a sum of knowledge about the nature, its properties and laws for application by human in different spheres of science and practice
Astronomical – a sum of knowledge about the origin and development of celestial bodies, the structure and evolution of the universe, its impact on the Earth
Physical - a sum of knowledge about inanimate nature, expressed on the basis of general physical principles, laws and regularities
Chemical - a sum of knowledge about natural and artificial substances, their structure, properties and transformations
Geographical - a sum of knowledge about the components of the geographical environment, their location and interactions on Earth
Biological - a sum of knowledge about wildlife, its structure, functioning and interactions with the environment

Figure 2. Components of Natural-Science Worldview (Source: Yakunchev & Semenova, 2018)

It is reflected in the below principles:

1. Consolidation of ideas about the general worldview and the scientific worldview in order to cognize the natural-science worldview with indication of its main components.
2. Study of the material on astronomical, physical, chemical, biological, geographical components of the natural-science worldview and determination of their scientific and practical value for solving the problems faced by the mankind.
3. Integration of the components of the natural-science worldview and reflection on the ideas about it.

The first principle consisting in the general idea of the world views and expression of their essence through studying natural sciences is best implemented at the introductory classes of physics, studied by senior students at upper secondary school. It is important to emphasize that physics is a science of the forms of matter and their interactions and motion. It is in the depths of physics that the scientific worldview is gradually developed. The teacher should display on the screen the meanings of concepts "general worldview", "unscientific worldview", "scientific worldview", "natural-science worldview". And here it should be noted that the composition and structure of the natural-science

worldview has been largely determined by physical science. This applies in particular to the largest discoveries of the 19th and 20th centuries, in particular the structure of matter and its interrelationship with different types of energy. It is recommended that the teacher when providing reasoning with regard to the essence of the natural-science worldview should make relevant comments from astronomy, chemistry, biology and geography. Figures 1 and 2 above may be used in the way of illustration.

The second principle consisting in the study of the material devoted to the components of the natural-science worldview may be successfully implemented at the classes of astronomy, physics, chemistry, geography and biology. In each case, as our experience has suggested, it is better to consider the material in a certain sequence: 1) Naming elements of the world view; 2) Brief description of the elements and the world view as a whole using the appropriate terms; 3) Discussion of the scientific and practical importance of knowledge about the world view under study to address the challenges faced by humanity.

When studying astronomy, it should be highlighted that this science studies the entire universe, cosmic space, celestial bodies and changes they undergo. It is important to talk with schoolchildren about the gradual development of the astronomical worldview, which appeared in a sufficiently well organized form in the first decades of the 20th century due to the emergence of cosmology as a branch of science. The main exponents of this worldview are four sections of knowledge, namely about the universe, the galaxies, the planetary systems and the stars. In the first case, the eyes of schoolchildren should be turned to the essence of the astronomical Universe as a whole material world, infinitely diverse in its forms of matter. In the second case, a giant system of stars with a common center of masses bound by gravitational forces and orbiting around this center. In the third and fourth cases, the system of stars, planets and their satellites, asteroids, comets and cosmic dust, which orbit around one center of the masses.

For a better understanding of the essence of the above knowledge it is recommended to use such terms as weight, shape, dimensions, density, pressure, temperature, chemical composition. It is important to refer to the discoveries made by famous scientists whose contribution to the development of the astronomical worldview was substantial. Today the knowledge of it bears great scientific and practical significance. The first aspect is that a person, having received the appropriate knowledge, begins to understand the phenomenon of existence of different forms of matter in the Universe, to recognize the importance of studying "the hidden matter", "the black holes" and the discovery of new types of matter not yet available to human perception. The second aspect relates to the use of space resources to solve the pressing issues, such as understanding the peculiarities of weightlessness, discovering new environments, clearing the outer space of debris, and abandoning military space programs.

When studying physics, it should be shown to the students that the physical worldview has also been evolving gradually. Today, it is expressed in four components, i.e. mechanical, thermodynamic, electromagnetic and quantum-field. In the center of the mechanical worldview is a classic Newtonian mechanics. It should be explained through the concepts of matter, space, time, movement and interaction.

The thermodynamic view of the world should be presented through the analysis of the energy conservation law with reference to the fundamental concepts of energy, motion, non-equilibrium and equilibrium thermodynamics. The electromagnetic view is based on the theory of electromagnetic field and the concepts of relativity, proximity effect, equivalence of inert and gravitational masses. The meaning of quantum-field view is better to explore with schoolchildren through material-wave notions while referring to such concepts as the particle (corpuscle), the wave (mechanical, electromagnetic), the field (gravitational, electric, magnetic).

When explaining the above material, it is important to assert that the formation of each subsequent view of the world led to the expansion and deepening of general knowledge about the world through revision of the previous ideas of it. This is the philosophical essence of physics reflecting the knowledge of the world accumulated on a purely objective basis. It would be good if the teacher could turn to the works of great physicists, the Nobel Prize winners. It is important for everyone to obtain the physical view of the world. The person should get convinced that the main substance of the world is the mixture of tiny particles constituting different forms of matter.

The change in idea of matter occurred from atomistic and corpuscular to continuum (continuous) and then to quantum conceptions of matter. In other words, the study of the physical view of the world is necessary for understanding the surrounding world from the point of view of science. From the point of view of practice, such a view is the basis for solving technical and technological problems, as well as the problems of world perception on the basis of an objective assessment of cultural values developed through the exact sciences.

In the study of geography, students' attention should be focused on the fact that the basis of the geographical view of the world is constituted by the human knowledge of the spatial nature of our planet and humanity. It should be emphasized that this statement is based not only on duality, but also on the multidimensional nature of the objects of geographical knowledge. Due to this, historically two discrete views have been developed, namely, the physico-geographical and the socio-geographical. Over a long while, they have been evolving autonomously through scientific search and certain success has been achieved. The main exponent of the first of them is the geographical envelope as the largest, most complicated and complex material formation of our planet, where the lithosphere, hydrosphere, atmosphere, pedosphere and biosphere constantly interact. Its constituent parts are natural territorial complexes located within certain territories/ water bodies, possessing the unity of nature and having the common origin, history of development,

as well as the originality of the geographical location and changes occurring with them. For their better comprehension by schoolchildren, it is recommended to use such terms as geographical space, geographical object, time, process, interaction, development, change, transformation, system, element. Reference to the discoveries made by the world-renowned geographers will help to better convey the material under study.

Socio-geographical picture is expressed by two components, social and economic. The first of them reflects the ideas about the existing population of the world, its regions, states and territories (population, fertility, mortality, density, sexual and age composition; demographic processes; racial, ethnic and religious differences; resettlement of people, urbanization, changes in the human potential). The second one reflects the peculiarities of territorial organization of production and territorial and compositional structure of economy of different countries and regions. The priority terms in this case will be humanity, population, demography, tertiary sector, productive forces, means of production and labor, location of production, division of labor.

The point of exploring the geographical view of the world by schoolchildren is that they get the generalized scientific ideas about the physico-geographical and socio-geographical arrangement of the Earth. Apart from that, they are introduced to the geographical culture, which indicators are geographical knowledge and skills (the interrelation of all components on the Earth and actions to maintain it), geographical thinking (globalism, prognosticity, systemacity, humanism), value orientations (nonacceptance of wars, disruption of exchange between the ocean and the atmosphere, destruction of living conditions in the biosphere), behavior in congruity with nature (for local endeavors).

When studying chemistry, it is important to note that the chemical view of the world is reflected through four sections of knowledge, namely, the doctrine of the composition of matter, the doctrine of structural chemistry, the doctrine of chemical processes and the doctrine of evolutionary

chemistry. As concerns the first position, the knowledge about the structure of the material world from the perspective of its chemical composition is of primary importance, the second represents the knowledge about the structure of chemicals and chemical bonds, the third is the knowledge about the diversity of chemical transformations, the fourth accumulates the knowledge about changes in the material world through natural and induced reactions in the process of chemical evolution. It is better to accompany the transfer of this knowledge with examples from the work of scientists in the field of quantum, atomic-molecular, physical and biological chemistry. The ideas of this worldview offer every person the grounds to assert that the surrounding world consists of substances that are characterized by a certain structure and the ability to mutual transformations. There is a close connection between the structure, the properties and the application of various substances. Therefore, the fundamental laws of chemistry are applied in science, technology, medicine and industry. Today, human life is not possible without chemical knowledge in the production of foodstuffs, drugs, and synthetic substances. The task of mankind is to regulate the production of chemicals, especially the weapons of destruction of living creatures on Earth, the historical and cultural values.

When studying biology, it is necessary to convey the meaning of the biological view of the world as an integral picture of living nature, expressed in the knowledge about its objects, their organization, functioning, interaction with the environment, as concentrated in the fundamental concepts, laws and theories for conscious use in various spheres of life. The main objects are taxonomic ones (for animals: species, genus, family, order, class, type, kingdom; for plants: species, genus, family, order, class, group, kingdom), biontological (organoid, cell, tissue, organ, organ system, organism), eidological (population, its components, interrelations between them and the environment), syneological (microbocenosis, mycocenosis, phytocenosis, zoocenosis, biocenosis, biogeocenosis,

ecosystem, biosphere). Their essence is better described by referring to the concepts of life, living matter, diversity of life, metabolism, homeostasis, genetic information, evolution, ecology.

The basic laws for representation of this worldview are biogenetic, uniformity of hybrids of the first generation, the law of splitting, independent inheritance of features, ratio between frequencies of genes and genotypes in the population, homological series of hereditary variability, germ similarity. The theories of primary importance are cellular, chromosomal theory of heredity, tiered arrangement of wildlife, anthropogenesis, synthetic theory of evolution, the major teachings include the teaching of homeostasis, of population, of biosphere, the key concepts are the concepts of noosphere and ecological system.

The biological view of the world is better fleshed out by reference to the works of scientists who made discoveries in the field of experimental and theoretical biology. For any person the knowledge about the biological view of the world bears a cognitive value in realizing that the life is continuous, it is sustained through a broad range of systems structured in a complex hierarchical way and interconnected through the genetic code of adaptations to the environment. The living matter on Earth creates a viable environment. Therefore, the preservation of biodiversity is one of the duties of humanity.

The third principle of the proposed scheme for the development of an idea of the scientific worldview among high school seniors implies integration of all components of the natural-science worldview and reflection on the ideas about it. It is recommended to implement it at the closing lessons of geography devoted to the consolidation of knowledge about the biosphere, its resources and their use by man. The idea of healthy functioning of our planet due to the interactions between its inanimate and living components may be used as an integrating force. It is important to bring the attention of schoolchildren to the fact that the diversity of interactions enables and sustains the livability on earth. The ideas about the astronomical view of the world give rise to the discussion

about the constants of global gravitation that determine the size of stars, the temperature and pressure inside them, the importance of different types of space energy, especially the solar energy, which determine the existence of life within the biosphere.

Based on the knowledge of the chemical view of the world, it becomes possible to analyze the role of all living things in the evolution of the earth, developing the thesis that there is no chemical force on the earth's surface, which is more permanent than the living organisms taken together. In other words, the face of the earth is formed by life enabled by different chemical reactions. Proceeding from the ideas about the biological worldview, it is possible to reveal with schoolchildren the phenomenon of the ubiquity of life in the biosphere. Life, gradually and slowly adapting, spreads across the biosphere and to a certain extent influences the functioning of the atmosphere, hydrosphere, lithosphere and pedosphere. Moreover, it is important to state that life is an intermediary between the Sun and the Earth, and therefore the amount of living matter may vary depending on the external energy indicators.

Based on the knowledge about the physical view of the world, it is possible to review with students the material about electromagnetic interaction, which determines the configuration of electron shells and the strength of chemical bonds that affect the existence of life. Knowledge of the geographical view of the world may be the basis for discovering the interrelations between the geographical envelope, its spheres and cosmic bodies. Besides, the worldview referred to above may provide grounds for analyzing the rational ways of using natural resources and the main directions for mankind towards sustainable development of society and nature.

As our experience has shown, testing of the presented materials during the study of certain subjects may yield positive results. It was manifested in the fact that the majority of high school students developed an ability to knowingly describe the essence of the scientific worldview, name and characterize its structural elements. They also purposefully and correctly applied their knowledge in

relation to the general characteristics of certain worldviews within the structure of the natural-science worldview.

CONCLUSIONS.

Results of testing of the proposed materials carried out by the teacher while delivering knowledge to high school students suggest the improvement in their knowledge of certain subjects. It has been manifested in several aspects.

The first is a clear definition of such concepts as "scientific worldview" and "natural-science worldview", as well as their components and characteristics at the level of understanding of high school students.

The second aspect is the recourse to the implemented in practice scheme for the development of the scientific worldview among the high school senior students with reliance on meanings of the aforementioned definitions.

The main exponents of the proposed scheme are the consolidation of knowledge about the scientific worldview, the components essential to its structure, its filling with specific material devoted to the astronomical, physical, chemical, biological, geographical components of the natural-science view of the world with the definition of their meaning for humans, the integration of the studied material and its presentation in a generalized form.

Implementation of the proposed scheme helps senior students to achieve certain educational results manifested in a meaningful expression of knowledge about the scientific views of the world differing by the level of generalization, characteristics of their components, interrelations between them, and their importance for the scientific and practical activities of a human.

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