Pedagogical conditions for the formation of the students’ scientific worldview when teaching biology

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Abstract. The theoretical aspects are revealed regarding the role of biology as one of the leading sciences of nature, in the formation of the students’ scientific worldview. It is emphasized that the content of the school subject “Biology”, methods, forms and means of study thereof, should be aimed at the formation of the students’ worldview. There are highlighted the main pedagogical conditions of the stepwise formation of the students’ worldview when teaching biology, taking into account the specific kinds of activity of the students and the teacher. As a structural unit of the pedagogical process there are designated the person-developing learning situations based on the relationship between the educational activity and life experience as well as the independent creative activity of the student, for the implementation of which the traditional content and techniques of teaching biology are reconstructed - the biological concepts of the worldview nature, creative tasks, problem situations, worldview-oriented issues with regard to the age-specific features of the students are emphasized. The obtained results of the pedagogical diagnostics, aimed at identifying the level of the formedness of the students’ scientific worldview, confirmed the effectiveness of the chosen pedagogical conditions.

1. Introduction

Worldview is an integral system of principles, views, values, ideals and beliefs that determine the direction of the person's activity and attitude to reality. Worldview is a set of scientific, philosophical, political, economic, legal, moral and aesthetic views, biological and other concepts of the place of man in nature and society, the character of one’s attitude to the environment and to oneself. Scientific knowledge, being included in worldview, releases a person from prejudices and misconceptions; moral principles and norms serve to regulate the relationship and behavior of people; philosophical views on the surrounding world, and beliefs are the foundation of such worldview which performs the function of awareness of worldview settings and historically defined pictures of reality. The qualitative characteristic of worldview includes the beliefs formed on the basis of knowledge, life and scientific-theoretical orientation, the system of views and values, ways of reality comprehension.

Each educational discipline at school, forming the circle of knowledge for students, contributes to the worldview development. It consists of elements of all forms of social consciousness: philosophical, scientific, moral, etc.

The experience of spiritual and practical development of the world is summarized in the worldview. The philosophical views based on the generalization of knowledge about nature and society, and explaining the laws of nature, serve as the core of any worldview.
2. Methods
The formation of the worldview is a complex process that is carried out throughout a person’s life, but it is especially intensive in school years, during the period of mastering the basics of science and experience of social life. Herewith, the worldview formation is determined primarily by the content of educational disciplines at school [1-5].

From the very beginning of studying the content of the subject of biology, students become familiar with the scientific system of views on the surrounding living world, nature, they lay the foundations of the scientific world perception. That is exactly why it is especially important for a biology teacher to define the system of scientific knowledge of worldview significance, to identify the pedagogical conditions and main stages of formation of the scientific worldview, to master the diagnostic methods for assessing the level of its formation [6-11].

A large contribution to the work on the analysis of the scientific and conceptual composition of biological education from the position of forming the scientific worldview, has been made by B.E. Raikov, N.M. Verzilin, I.D. Zverev, D.I. Traitak, V.N. Maksimova, V.P. Solomin, B.D. Komissarov, A.N. Zakhlebny, V.V. Nikolina, I.N. Ponomareva, O.G. Rogovaya, N.D. Andreeva, and others. More than 40 years ago, N.M. Verzilin and V.M. Korsunskaya, pointing out the role of biological education in the formation of the students’ worldview, wrote that biology as an educational subject is of the exceptional value for the development of the materialistic worldview, since its material is available for observation, and requires logical conclusions on the basis of the observed facts and phenomena.

The development of natural science knowledge in the school course “Biology” goes from simple to complex, with the discovery of cause-and-effect relations, logic, comparisons and proofs. The acquired knowledge of the properties of living nature helps pupils to comprehend and accept certain ideas, value orientations and views that lead to the worldview belief. It is the worldview beliefs that express the pupil’s attitude toward reality, encourage him/her to act in accordance with his/her views, ideas and principles. An important element of the worldview formation is the development of the pupil’s humanistic view, which in a concentrated form reflects the values-based attitude toward a person. The worldview formation does not only come down to the acquisition of worldview knowledge, but is also connected with the formation of one’s own internal position and attitude toward the real world [12-14].

3. Results
Methodological research and experience of biology teachers make it possible to highlight the following main conditions of the worldview formation.

- The teacher’s deep philosophical awareness of the entire system of the principal biological laws, theories and concepts of great importance for the formation of students’ worldview.
- Coordination of the content of the worldview material on biology with the content of other educational subjects for the formation of the picture of the world, i.e. the use of cross-curriculum connections.
- Sequential identification and evaluation of each stage of the educational-bringing-up process in biology, in terms of its role and possibilities of contribution to the process of the students’ worldview formation.
- Activation of the students’ cognitive activity aimed at understanding and comprehension of the fundamental ideas and concepts, the development of aspirations to become aware of their importance for understanding the general laws of wildlife. For this purpose, various types of pedagogical technologies are used, among which the most effective are the technologies of development of critical thinking, problem-based and dialog learning, the organization of creative independent work of students, research and project activities, etc., which develop reflexive mechanisms of thinking, self-analysis, self-control, activate the interest in worldview issues, contributing to the development of independent creativity. 5. Systematic monitoring of the degree and quality of the students’ understanding of worldview issues, determination of their attitude toward the absorbed knowledge of nature; determination of the degree of not only the
completeness of knowledge but also its conversion into one’s own views and beliefs. Methodically reasonable is the statement of questions aimed at highlighting the main content of the educational material, determination of the students’ own position, the nature of its development, conviction in their knowledge, in the aspiration to find out new, significant aspects of theoretical generalizations. In this regard, there occurs not only the awareness of knowledge and its conversion into one’s own beliefs but also the correction in understanding of the most essential.

- Development of the students’ needs to apply the biological knowledge in educational and practical activities in which the students’ attitude toward reality, their views, firmness of beliefs, correctness of the actions and behavior in different life situations, are displayed. This is implemented through solving creative tasks, problem situations, participation in business and role-playing games, reflection in the field of self-knowledge and a course of action, development and implementation of projects, using interactive methods (Case method, POPS-formula, brainstorm, etc.), organizing practical activities in extracurricular work (in the biology classroom, at the school educational-experimental plot, during the performance of nature protection measures), etc.

The formation of the students’ scientific worldview in teaching biology can be considered as a stepwise process which is characterized by specific types of activities of students:

- perception of the problem of scientific comprehension of facts and phenomena of the surrounding reality;
- comprehension of scientific biological theories, regularities, concepts;
- manifestation of personal relationships, confidence in the truth of scientific knowledge;
- practicing, application of one’s views in the activity;
- generalization of worldview opinions at the achieved level of their development;
- Specific types of activities of a teacher are as follows:
  - assigning specific tasks for the worldview formation (at lessons or other forms of organization of the educational process);
  - disclosure of the leading ideas, theories, concepts as regards the worldview;
  - monitoring of the perception of the worldview material and managing this process;
  - taking into account the results of the worldview formation process;
  - assigning new goals and characterizing the level of their achievement (generalization).

For the effective implementation of the process of the students’ scientific worldview formation at all stages, we considered the specially organized person-developing educational situation as a structural unit of the pedagogical process. One of the most important conditions for implementation thereof in teaching biology is the relationship of educational activities with the life experience and independent creative activity of the student. In accordance with this, the traditional content of the school subject "Biology" was reconstructed: emphasis was made on the biological concepts of the worldview character, creative tasks, problem situations, worldview-oriented questions that contributed to the manifestation of the students’ interest in the knowledge having the worldview character, the manifestation of initiative and creativity.

In the process of studying biology in the 6th form, the teacher forms the students’ system of views on wildlife, their attitude toward the natural environment. During the lessons, excursions, after-hour and extracurricular activities, when the whole variety of teaching methods is used, students gradually form the biological picture of the world – the organism is considered as a whole and in connection with the environment, the importance of plants and the whole variety of the vegetative world in nature, and its ability to develop are realized. The zoological material (7th form) on the diversity of the animal world in connection with the conditions of existence, starting from protozoans and ending with mammals,
forms the students’ understanding of the fact of existence of living objects, the peculiarities of living creatures, the originality of plants in comparison with animals, the dependence of both on the environment.

It is known that students of forms 6-7 have the predominant concrete-imaginative thinking, they experience difficulties in implementing not only mental but also objective, imaginative analysis and synthesis. Generalizing, operating abstract concepts, making the transition from knowledge reproduction to the ability to use it to stick up for scientific views, cause difficulties for students. These features of mental and psychological development of adolescents create certain difficulties in solving the problems of the students’ scientific worldview formation. The difficulties in solving the problem are also caused by the fact that students of 12-13 years of age have a limited store of the scientific knowledge in geography, physics, chemistry, which is necessary for leading up to the conclusion of the material unity of wildlife and inanimate nature. All mentioned features of the content of the courses of botany (6th form) and zoology (7th form), the level of mental and intellectual development should be taken into account when choosing technologies, methods and means of teaching in the students’ worldview formation.

Similarly, the materials of the course on man (8th form) deepen the scientific knowledge of the properties of living organisms. When studying the structure and functioning of a number of organ systems – digestive, blood circulatory, respiratory, nervous, excretory, etc. – students learn about the evolutionary advancement of man in comparison with previously studied animals. Besides that, they learn not only the biological properties of man but also man’s social characteristics.

The materials of the course of general biology (forms 9-11) are equally meaningful for the students’ worldview formation. Expansion of the range of knowledge of nature and society through the cross-curriculum connections with the courses on chemistry, physics, geography, social science, gives students the opportunity to more fully cognize the essence of biological phenomena, their place in the overall picture of the world, establishing the relationship of biological, physical and chemical phenomena of nature, the synthesis of natural-scientific and philosophical knowledge.

The teacher should pay special attention to the construction of the educational process taking into account the age characteristics of the students. Inherent to senior pupils are abstract thinking, a tendency to philosophical generalizations, to critical evaluation of their own activities, actions of other students, which is especially valuable for the development of natural-scientific knowledge and turning it into their own beliefs [15-16].

Taking into account the age characteristics and specifics of the school biology courses at the formation of the scientific worldview, it is advisable to use various techniques for creating problem situations of the worldview character. Here are some of them.

- The teacher’s posing a problematic question, including one formulated in accordance with the topic of the lesson. For example, in consideration of the material on the features of the structure of the human skeleton, a problematic question is formulated: “Man belongs to the class of mammals, but the man’s skeleton differs from that one of other mammals. What is the reason for this?” Solving this problem will help students make conclusions on the big role of social factors in the human development and formation.

- Posing a problematic question that requires the student’s reflections on the basis of the known factual material, hypothesizing, formulation of conclusions contributing to the formation of the coherent scientific picture of the world. The problem situation that the teacher creates when studying the type “Protozoans” can serve as an example of the situation leading the students to the conclusion about the unity of flora and fauna. So, when studying the green euglena, students, on the basis of the description of this living organism offered in the textbook, should express the reasoned assumptions about what the green euglena is – a plant or an animal – and formulate what the intermediate position of this organism between flora and fauna indicates.

- Inducing students to theoretically explain phenomena, facts, external discrepancies between them. This causes the search activity of students and leads to the active acquisition of new
knowledge. This situation is properly illustrated by the example of the lesson conducted in the 8th form on the topic “The structure of the heart”. At the beginning of the lesson the teacher tells about the doctor, founder of scientific anatomy A. Vesalii, who in the presence of the audience dissected the corpse to determine the cause of death, and found a slightly working heart. Why did the corpse's heart beat? No one could answer this question, not even Vesalii himself, because the level of knowledge in that era was still very low. The answer to this question was only given to mankind in three centuries. After listening to this story, the students thought about the phenomenon that required theoretical substantiation.

- Setting the educational problematic tasks for the explanation of a phenomenon or the search for its practical application. Any research work of students in the biology classroom, at the school educational and experimental plot can serve as an example.

- Inducing students to perform the analysis of facts and phenomena of reality, which generates contradictions between the everyday visions and scientific concepts of these facts. For example, students know well that the increase in the body temperature indicates the inclusion of the body defences in the fight against the disease. At the same time, the patient is prescribed medications that lower the temperature. A problem situation is created. Here is evident the contradiction between the existing knowledge (as well as the life experience of students) and a new fact, for the explanation of which new knowledge is required.

- Students’ acquaintance with the facts that are as if of an inexplicable nature and lead to the statement of a scientific problem in the history of science. Usually, these facts and phenomena seem to contradict the students’ existing views and concepts, which is explained by the incompleteness of their previous knowledge. So, at the biology lesson on the topic “Noncellular organisms” after the talk about the discovery of viruses, their structure and history of study, the teacher tells: “The bacterial cell was opened five minutes after the virus entered it. The cell was empty, and no virus was found in it. But when they opened the cell in twenty minutes, they found that it was already infected with new phages.” What happened in the cell within twenty minutes? How did a single virus manage to create 300 of its own kind during that time? Such facts, which at first glance are inexplicable for students, generate a problem situation.

- Organizing the school experiment, including self-observations of the students. When studying the topic “Metabolism”, students are offered to carry out an experiment to determine the time of breath retention before and after the exercise. The results of the experiment lead the students to the comprehension of the dialectical connection of the energetic and constructive metabolism as the unity and struggle of opposites, to the discovery of the law of energy conservation and metabolism.

In the process of the scientific worldview formation, it is important to use the work with natural aids, the organization of observations in nature, at the consideration of the observed objects, laws there should be applied the techniques of generalization, comparison, systematization and proof in revealing the properties of different biosystems. Leading the students to the conclusion on the materiality of the surrounding world will be successful if the teacher implements the methodic requirements for the organization of the educational process:

- the use of natural visual aids at the lessons (they contribute to the creation of sufficiently complete concrete representations of the studied subjects, on the basis of these representations work is carried out on identification of the essential properties of subjects, i.e. concepts are formed);

- organization of students’ observations in nature;

- demonstration of experiments clarifying the essence of the physiological processes of nutrition, respiration, growth, development, etc. (at demonstration of the experiments, cognitive tasks are formulated for students to guide the observation and lead them to a certain conclusion);
• arrangement of work with a microscope (this convinces the students of the real existence of the world invisible to the eye);
• organization of the excursion at the consideration of the issue on the development of thinking in the process of anthropogenesis, which proves to the students as follows: consciousness is the result of functioning of the cells of the cerebral cortex (herewith, based on the students’ knowledge of the evolution of the nervous system, we bring them to the conclusion on the materiality of the world);
• organization of the laboratory work of students with the handout natural material.

Let’s illustrate the last item. When studying the topic “Heredity and variability”, to bring the students to the conclusion that variability and heredity are opposite properties inherent to every living organism and manifested in unity, the teacher must use indoor plants of the same species: their comparison showed similarity (manifestation of the property of heredity) and difference (manifestation of the property of variability). To draw the conclusion that the variability is of the divergent nature, can be useful, harmful and indifferent, there was used work with ears of wheat of the same species and grade, pods of leguminous plants of the same species. While measuring objects, the students made sure that the variability fluctuates around a certain average value, meanwhile there are deviations in the direction of both useful and harmful for the organism. These conclusions, made at the lesson on the topic “Artificial selection”, led the students to understand that due to the divergent nature of variability, breeders are able to find, among the large number of individuals, the changes that correspond to the goal set by the breeder, and in the future to perform the work on creating the grade, breed.

At the lesson “Natural selection”, using the students’ knowledge of the divergent nature of variability, it is possible to lead them to the conclusion that in natural environment, there also takes place the selection of organisms by the characteristics that correspond to the ambient medium conditions. These conclusions are the result of the good acquisition of facts during the period of independent work with the natural material.

4. Discussion
The most important stage in the biology teacher’s work on the students’ scientific view formation is the diagnostics of the development of the scientific worldview of the student, the essence of which is as follows:

• study and detection of changes in the state of development of the scientific worldview formation;
• determination of the level of the scientific worldview development;
• finding out the reasons that determine the revealed state of the scientific worldview;
• determination of the conditions for improving the level of the person’s scientific worldview development.

A significant element of the students’ worldview formation is the biology teacher’s diagnostic skills in the study of the state of the students’ scientific worldview development level, including the skills below:

• to assign diagnostic tasks;
• to define the criteria and indicators of the level of the students’ worldview formation;
• to select the system of diagnostic methods and implement it;
• to determine the effectiveness of the organized pedagogical interaction for the purpose of the students’ worldview formation;
• if necessary, to make adjustments to the process of the students’ scientific worldview formation [17-18].
The effectiveness of the biology teacher’s work on the students’ scientific worldview formation is manifested as follows:

- in the answers of students, which is found in the ability to establish phylogenetic relationships; to reveal the interaction of phenomena; to reveal the contradictory nature of internal connections; to prove the objectivity of knowledge of nature, to give a scientific explanation of phenomena, to show the falseness and antiscientific nature of idealistic statements;
- in the students’ abilities to apply the knowledge of general provisions to the explanation of concrete phenomena, to draw independent conclusions from the studied material, to defend and prove their views and beliefs;
- in the behavior of students, their moral appearance, active participation in labor processes, in the work on nature protection.

5. Conclusions
Evaluation of the effectiveness of the teaching technique aimed at the students’ scientific worldview formation in teaching biology, was carried out on the basis of the continuous comparison (forms 6-11) of the level of this personal quality formation as regards the trainees of the experimental and control groups. Herewith, there was noticed an increase in the number of students in the experimental classes with high (by 5 %) and average (by 7 %) levels of the scientific worldview formation. Thus, the research confirmed the appropriateness of the chosen pedagogical conditions for the students’ scientific worldview formation in teaching biology.

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