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Formation of Bioethical Knowledge in Adolescents during Their Biology Education

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Abstract: *The article highlights the methodology for forming bioethical knowledge in adolescents during their biology education, which involves the actualization of bioethical aspects in the content of the educational material and the use of verbal, visual, interactive, problem-based, and project-based teaching methods. To actualize the bioethical aspects of the educational material, the content of the school subject of "Biology" was supplemented with bioethical information that provides an opportunity to establish analogies between the general laws of living nature and moral categories, and cards with ethical dilemmas were developed, the use of which contributes to the formation of the ability to make moral choices. While implementing the methodology for forming bioethical knowledge in adolescents, verbal teaching methods were used to explain new educational material and establish analogies between the general laws of living nature and the categories of morality. Verbal teaching methods were combined with visual methods and problem-based learning. Interactive teaching methods were used to solve moral dilemmas and stimulate cognitive engagement at various stages of the lesson. In implementing the methodology for forming bioethical knowledge, high schoolers carried out information search projects that involved integrating biology and ethics knowledge. The use of various teaching methods to implement the methodology for the formation of bioethical knowledge contributed to the development of high schoolers' cognitive motives, the formation of conscious bioethical knowledge, emotional perception of living nature, and value attitudes towards them.*

Keywords: *bioethics; bioethical knowledge; biology lessons; adolescents; general secondary education institutions.*

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Introduction

One of the features of the current stage of society's development is the active use of biological research results in various sectors of the economy, medicine, and pharmacy. However, in addition to the benefits, this can lead to inhumane treatment of animals, violations of biosafety, and ethical issues related to the use of living organisms. This actualizes the need for children and young people to develop bioethical knowledge based on the awareness of the value of life in all its manifestations. The most favorable period for the formation of this bioethical knowledge is adolescence. It is during this age period that the moral norms of society are learned, the need to comply with them is understood, and the moral and ethical values of the individual are formed.

The school subject of "Biology" has significant potential for forming bioethical knowledge. Knowledge of biology provides an understanding of the dialectical unity of the general laws of living nature and the moral life of man, forms an idea of the biosocial essence of a human being, and raises awareness of the need for behavior based on biocentrism. Given the above, substantiating the methodological principles of forming bioethical knowledge in adolescents during their biology education is an urgent task of pedagogy and methods of teaching biology.

Analysis of the latest research

As a biological being, a human lives according to nature's general laws. Their existence is subject to species, ecosystem, and biosphere laws. At the same time, a person lives in a society with social traits related to moral choice and ethical behavior. Therefore, the opinion of scientists who note that human life and health, as well as the preservation of all living organisms, are the object of study not only in biological but also in the social sciences and humanities (Hryniova, 2016; Zaporozhan et al., 2021; Stepaniuk & Drabyk, 2023). This has led to the development of bioethics, a science that integrates biology with ethics to address the problems of protecting the physical and spiritual integrity of humans, the survival of humans as a species, the formation of an ethical attitude towards living organisms, the preservation of the biosphere and the global survival of civilization (Pare, & Bergeron, 2022).

In the educational process, bioethical knowledge is the emergent result of integrating biology and ethics knowledge (Iancu, 2018; Stepaniuk, & Bak, 2024; Pitsou et al., 2025). Also of interest is the study concerning the

evolution of the axiology in education (Dyiak & Volobuiev, 2025), which addresses various aspects of historical and philosophical aspect in the context of the Russian-Ukrainian war. Researchers also study the students' self-government in the framework of their organizational culture formation (Miroshnichenko, et al., 2024), decision-making skills and students' cognitive independence as a leading factor of their successful education (Bloshchynskyi, et al., 2023).

The problem of forming bioethical knowledge of general secondary education (GSE) high schoolers has been thoroughly studied in pedagogical research. Scientists emphasize that the formation of an ethical attitude to nature and bioethical knowledge is an essential component of the educational process and a necessary condition for the moral development of the individual (Pyholenko, & Pyholenko, 2011; Narvaes Lozano et al, 2022; Enns, & Renk, 2025), and also note that today there is a need to organically incorporate into the educational process a system of emotional and value knowledge based on universal values (Tarasenko, & Halych, 2022); moral and ethical and bio(eco)ethical fostering of children and youth (Ozkan, & Umdu Topsakal, 2016); formation of ecobioethical culture in high schoolers (Pinskyi, & Yeriemieieva, 2022; Calderon, & Tan, 2023).

To form bioethical knowledge in high schoolers, scientists and methodologists propose to carry out the educational process taking into account the principle of humanization of education, which involves appealing to spiritual values and moral principles that should permeate all school subjects (Zhyrska, & Nazarko, 2007); to implement a personality-oriented approach to teaching, from the standpoint of which the assimilation of educational content involves the actualization of the subjective meaning of personal values in the educational material, to actualize bioethical aspects in the content of the educational material (Buck, 2015); to draw high schoolers' attention to the problem of the value of nature and to form an ecological culture (Zhyrska, 2014); to integrate into the content of natural science subjects educational material on ethical issues of the relevant science, moral norms and principles (Dawson, 1999; Hubenko, 2020; Stepaniuk, & Bak, 2024; Wang, 2024).

Several studies are devoted to the scientific substantiation of means, methods, and technologies for forming bioethical knowledge. Scientists prove the effectiveness of visual learning tools that can draw high schoolers' attention to bioethical issues (bioethical videos, comics, memes) in the formation of bioethical knowledge (Ike, & Anderson, 2018; Pinskyi, 2020); Internet resources that provide wide access to teaching and learning support and allow visualization of educational material (Hawkins, & Stark, 2015);

suggest the use of interactive teaching methods (discussions, debates, game methods) (Hudha et al, 2018; Kedraka, 2020); implement project-based learning in bioethical education (Tham, 2024); to solve ethical dilemmas in the study of biology (Bak, 2015; Narvaes Lozano et al., 2022; Keskin-Samanci et al., 2014).

After analyzing scientific works on the problem under study, two aspects of bioethical knowledge formation have been identified: content-based and procedural. The content-based aspect involves covering moral values and norms of behavior in educational material. The procedural aspect requires the use of teaching methods and technologies aimed at the individual's inner world and the transformation of the objectively necessary into the subjectively significant.

Adolescence is a favorable period for the formation of bioethical knowledge. According to scientists, this is because the peculiarities of adolescence are the desire to be an adult, the need for self-affirmation and self-realization, the development of reflection, and the awareness of the need to adhere to the moral norms of public life (Nevmerzhytskyi, 2023; Pryshchepa, 2019). These peculiarities make adolescence sensitive to the development of the individual's value orientations and moral principles.

Bak (2015), Kedraka (2020), Ozkan, & Umdu Topsakal (2016), Stepaniuk & Budnyk (2021), Trotsko (2010) argue that the school subject of "Biology" has significant potential for the formation of bioethical knowledge. At the same time, Onipko et al. (2017), Iancu (2014), and Hudha et al. (2017) note that only biology teachers with high moral qualities and guided by bioethical principles and norms can form bioethical knowledge in high schoolers.

Despite the importance of the problem of forming bioethical knowledge, the content of general secondary education in Ukraine does not pay enough attention to the value aspects of biology and its connection with the humanities. The content of the biology educational material covers only certain aspects of bioethics, and the curriculum does not include such a learning outcome as bioethical knowledge. Given the relevance of the problem of forming bioethical knowledge in high schoolers and the lack of attention to it in the educational process of general secondary education, the **research aims** to develop a methodology for forming bioethical knowledge in adolescents during their biology education and checking its effectiveness.

Methodology

The research was conducted over three years (from 2023 till 2025). The experimental research involved 180 high schoolers in grades 7-9 from

general secondary schools in four cities of Ukraine (Khmelnytskyi, Lutsk, Ternopil, and Rivne). According to the age periodization, the age of 7th-9th-grade high schoolers (13-15 years old) corresponds to adolescence.

The experimental research work included four stages: search, ascertaining, formative, and generalizing. At the search stage, the analysis of scientific and educational literature on the research problem, normative documents regulating the content of biological education in general secondary schools, was carried out; a methodology for the formation of bioethical knowledge in adolescents during their biology education was developed. The following research methods were used: analysis, systematization, and generalization to process literature sources and determine the main directions of scientific research; designing the content and methods of forming bioethical knowledge in adolescents.

At the ascertaining stage of the experimental research work, the criteria, indicators and levels of bioethical knowledge formedness in adolescents were determined; diagnostic tools for determining its formedness were selected; the experimental research base was chosen; the existing level of bioethical knowledge formedness in adolescents was determined.

According to the results of determining the levels of formation of bioethical knowledge at the ascertaining stage, a control and experimental group of students (CG and EG) were formed. The groups were formed in such a way that each of them included six classes (two seventh, two eighth and two ninth). To ensure the reliability of the results of the experimental research work, the absence of statistically significant differences between the levels of formation of bioethical knowledge in students of the CG and EG was determined using the Pearson 2 criterion. As a result of the calculation, it was established that the empirical value of the Pearson 2 criterion for all classes is in the non-significance zone, that is, the levels of formation of bioethical knowledge of students do not differ significantly.

The following research methods were used to solve the tasks of the ascertaining stage of the experiment: analysis and systematization to determine the criteria, indicators and levels of bioethical knowledge formedness; pedagogical experiment (ascertaining stage); questionnaire, testing and analysis of high schoolers' learning outcomes to determine the levels of bioethical knowledge formedness; comparison and generalization to process the results of the pedagogical experiment; methods of mathematical statistics (Pearson's criterion ($\chi 2$)) to determine the reliability of the results of the pedagogical experiment.

At the formative stage of the experimental research work, the methodology for forming bioethical knowledge in adolescents during their biology education in the EG was introduced into the teaching process. In the CG, the teaching process was carried out according to the traditional methodology.

To solve the tasks of the formative stage, the following research methods were used: pedagogical experiment (formative stage); questioning, testing and analysis of high schoolers' learning outcomes to determine the levels of bioethical knowledge formedness; comparison and generalization to process the results of the pedagogical experiment; methods of mathematical statistics (Pearson's criterion ($\chi 2$)) to determine the reliability of the results of the pedagogical experiment.

At the generalizing stage of the experimental research, the results were summarized, and conclusions about the achievement of its aim were formulated. The following methods were used to process the experimental data and formulate general conclusions: analysis, comparison, systematization, and generalization.

Results

The effectiveness of the methodology developed in the research was determined by comparing the levels of bioethical knowledge formedness in the CG and EG high schoolers. It was taken into account that bioethical knowledge is multidimensional and should be determined by cognitive, activity-oriented, and value-based criteria. The diagnostic tools used to determine the formedness of bioethical knowledge are presented in Table 1.

Table 1. Diagnostic tools used to determine bioethical knowledge formedness in adolescents

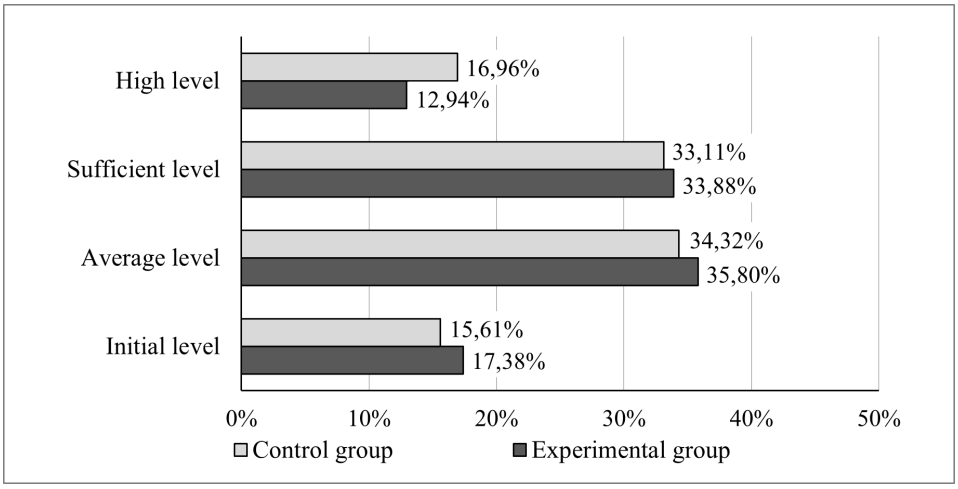
Criterion	Indicator	Diagnostic tools
Cognitive	Systematic and conscious bioethical knowledge	Training tests in biology
Activity-oriented	Ability to use knowledge of the general laws of living nature to justify the rules and norms of ethical human behavior	Information and research projects: Grade 7 – "Bioethical Attitude to Animals"; Grade 8 – "Bioethical Aspects of Modern Reproductive Technologies"; Grade 9 – "Bioethical Aspects of Biotechnology and Genetic Engineering"
Value-based	Values are based on the moral principles of society and the individual	Testing to determine the dominance of the subjective attitude to nature (the "Dominant" test) and to determine moral values (the "Value Priorities" test)

The distribution of high schoolers by levels of bioethical knowledge formedness at the ascertaining stage of the pedagogical experiment is presented in Table 2 and Figure 1.

Table 2. Distribution of the CG and the EG high schoolers by the levels of their bioethical knowledge formedness at the ascertaining stage of the pedagogical experiment

Number of high schoolers	**Formedness levels of learning achievements**							
	High		Sufficient		Average		Initial	
	No.	%	No.	%	No.	%	No.	%
Grade 7								
56 (CG)	9	16.07	20	35.71	19	33.93	8	14.29
54 (EG)	7	12.96	18	33.33	19	35.19	10	18.52
Grade 8								
54 (CG)	8	14.81	16	29.63	20	37.04	10	18.52
53 (EG)	6	11.32	15	28.30	19	35.85	13	24.53
Grade 9								
50 (CG)	10	20.00	17	34.00	16	32.00	7	14.00
55 (EG)	8	14.55	22	40.00	20	36.36	5	9.09

Figure 1. Histogram of the distribution of the CG and the EG high schoolers by the levels of their bioethical knowledge formedness at the ascertaining stage of the pedagogical experiment



Based on the analysis of the results of the ascertaining stage of the pedagogical experiment, it was concluded that 7th-9th-grade high schoolers have an average and sufficient level of bioethical knowledge formedness. It is also worth noting that the most significant number of high schoolers with

an initial level of bioethical knowledge formedness is in grades 8. In our opinion, this is because the age of 14 is the culmination of the adolescent crisis. The unwillingness to learn is the most pronounced at this age. This is due to inattention, emotional instability, and a negative attitude toward the surrounding reality. We attribute the lower percentage of high schoolers with an initial level of bioethical knowledge formedness in the 7th grades to the fact that at 13, the crisis of early adolescence continues, which is not characterized by pronounced negativism. In the 9th grades, the lower percentage of high schoolers with an initial level of bioethical knowledge formedness, in our opinion, is because the crisis of adolescence ends at the age of 15. In this age, negative attitudes toward reality are replaced by the desire for social recognition and "acquiring a moral face."

The methodology for forming bioethical knowledge considered the content-based (actualization of bioethical aspects in the content of the educational material) and procedural (use of verbal, visual, interactive, problem-based, and project-based teaching methods) aspects.

To actualize the bioethical aspects, the content of the school subject of "Biology" is supplemented with educational material (additional information) that allows to establish analogies between the general laws of living nature and the categories of morality, such as good, evil, honesty, duty, justice, freedom, conscience, honor, dignity, gratitude, respect, compassion, mutual assistance, equality, fairness, approval, generosity, self-control, responsibility, the meaning of life, etc. An example of educational material (additional information) with bioethical content for some topics is presented in Table 3.

Table 3. Educational material (additional information) in the content of the school subject of "Biology".

Topic	**The category of morality**	**Educational material for establishing analogies with moral categories**
Grade 7		
Scientific research as a method of cognition. Biology as a science	Perseverance, the meaning of life	Examples of purposeful and highly moral behavior of life scientists
Features of animals. The place of animals in ecosystems and their importance to humanity	Gratitude	Demonstrating examples of the importance of animals in human life (farm animals, equine-assisted therapy, canine-assisted therapy, etc.)
	Duty, responsibility, self-control	The need to treat animals and their communities with care
	Compassion,	The need for humane treatment of

	kindness	animals, solving the problem of stray animals, condemnation of the use of animals in circus performances, and for entertainment
	Good, evil, honor, dignity, love	Legends about animals
	Evil	Negative human impact on the animal world (destruction of animal habitats, poaching, inhumane treatment of animals, etc.)
Humanity's impact on ecosystems. The concept of sustainable development	Respect, equality	Ecocentric approach to environmental management
	Cooperation	International cooperation in solving environmental problems
Grade 8		
Support and movement	Compassion, mutual assistance	First aid for injuries of the musculoskeletal system
Digestion of nutrients	Self-control, responsibility, duty	The importance of rational nutrition, prevention of diseases of the digestive system
Higher nervous activity	Self-control, responsibility, duty	Indicators of nervous processes, the role of self-education in personality formation
	Good, evil, honor, dignity, the meaning of life	The influence of social factors on personality formation
Human reproduction and development	Self-control, responsibility, duty, and the meaning of life	Prevention of sexually transmitted diseases, the need to preserve reproductive health, and a healthy lifestyle as a prerequisite for the birth of a healthy child
The biosocial nature of a human being	Good, evil	Ethical aspects of medical experiments, genetic modification, and relations between people in society
Grade 9		
Patterns of trait inheritance	Good, evil, and the meaning of life	Ethical aspects of modern reproductive technologies, the importance of genetic counseling, and molecular diagnostic methods in contemporary genetics
	Self-control, responsibility,	The impact of parents' bad habits and environmental factors on offspring

	duty	
Supra-organizational biological systems	Good, evil, honor	Anthropogenic impact on natural ecosystems
	Duty, self-control, equality, responsibility	Ecological culture in everyday life, civic position in the field of environmental protection
Biology as the basis of biotechnology and medicine	Good, evil, approval, responsibility	Advantages and possible risks of using genetically modified organisms, positive and negative consequences of modern biotechnology, and moral and social aspects of biological research

The educational material (additional information) of bioethical content was used at different stages of biology lessons to create problem situations and foster high schoolers' cognitive activity. Coverage of the connection between the general laws of living nature and the categories of morality in the content of the school subject of "Biology" contributed to high schoolers' awareness of the value of life in all its manifestations, understanding of the biosocial nature of a human being, and the formation of the ability to be guided by moral principles and make nature-based decisions.

Ethical dilemmas were also selected to form bioethical knowledge in high schoolers, and cards illustrating them were developed. For example, in the 8th grade, the biology class discussed an ethical dilemma regarding the biosocial nature of human beings, and in the 9th grade, the ethical issues of modern reproductive technologies, artificial changes to DNA, and the genome of living organisms. The situation of choice in solving an ethical dilemma encouraged high schoolers to "immerse" themselves in the problem and make a moral choice. This often led to disputes, in which high schoolers acquired new knowledge and skills to justify and defend their opinions.

Verbal teaching methods (explanation, narration, conversation, storytelling) were used to explain new educational material and establish analogies between the general laws of living nature and moral categories when implementing the methodology for forming bioethical knowledge. For example, in the 7th grade, when studying the diversity of birds and mammals, the storytelling method was used to tell high schoolers legends about animals that highlighted such moral categories as good, evil, love, and sincerity.

When developing bioethical knowledge, verbal teaching methods were combined with visual methods (showing videos, using cards with

ethical dilemmas) and problem-based learning. For example, in the 8th grade, when studying the topic referred to as "The Biosocial Essence of a Human Being," a problem situation was created that forced high schoolers to think about the moral and ethical aspects of medical experiments, genetic modification of living organisms, and relations between people in society.

Interactive teaching methods (discussion, debate, brainstorming, etc.) were used to solve ethical dilemmas. For example, in the 9th grade, ethical dilemmas regarding modern reproductive technologies and artificial changes to the genome of living organisms were discussed and resolved during a discussion. After thinking about the ethical dilemma, high schoolers presented their ideas and discussed the points of view of other high schoolers. Interactive teaching methods helped high schoolers develop a positive emotional perception of wildlife objects and phenomena, resolve internal contradictions in communication with nature, and develop a subjective attitude towards it. Also, interactive teaching methods stimulated cognitive engagement at various stages of the lesson.

The project-based learning method was used to implement the methodology for forming bioethical knowledge. High schoolers completed information and research projects on the following topics: "Bioethical Attitude to Animals" (Grade 7), "Bioethical Aspects of Modern Reproductive Technologies" (Grade 8), and "Bioethical Aspects of Biotechnology and Genetic Engineering" (Grade 9). The projects contributed to the formation of high schoolers' cognitive motives and value-based life orientations.

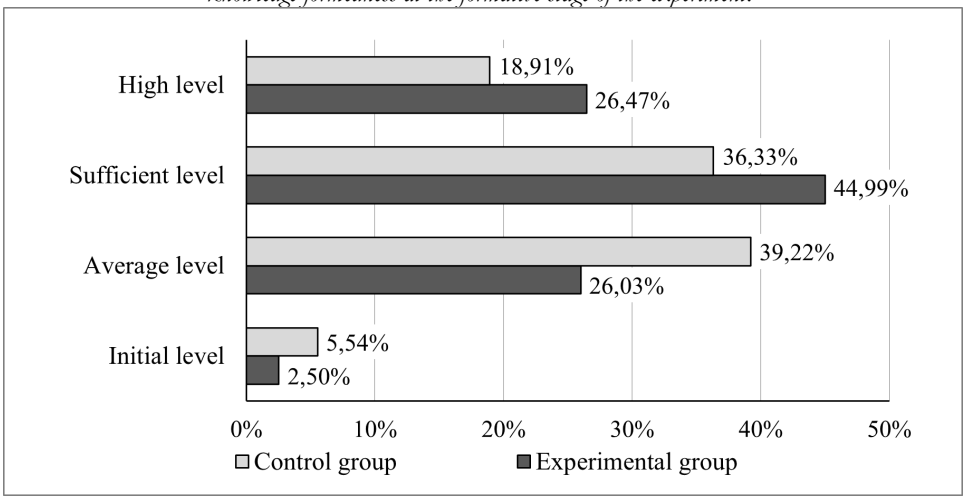
The distribution of high schoolers by levels of their bioethical knowledge formedness at the formative stage of the pedagogical experiment is presented in Table 4 and Figure 2.

Table 4. Distribution of the CG and the EG high schoolers by the levels of their bioethical knowledge formedness at the formative stage of the pedagogical experiment.

Number of high schoolers	**Formedness levels of learning achievements**							
	High		Sufficient		Average		Initial	
	No.	%	No.	%	No.	%	No.	%
Grade 7								
56 (CG)	9	16.07	21	37.50	23	41.07	3	5.36
54 (EG)	14	25.93	24	44.44	15	27.78	1	1.85
Grade 8								
54 (CG)	9	16.67	17	31.48	23	42.59	6	9.26
53 (EG)	11	20.75	21	39.62	18	33.96	3	5.66
Grade 9								

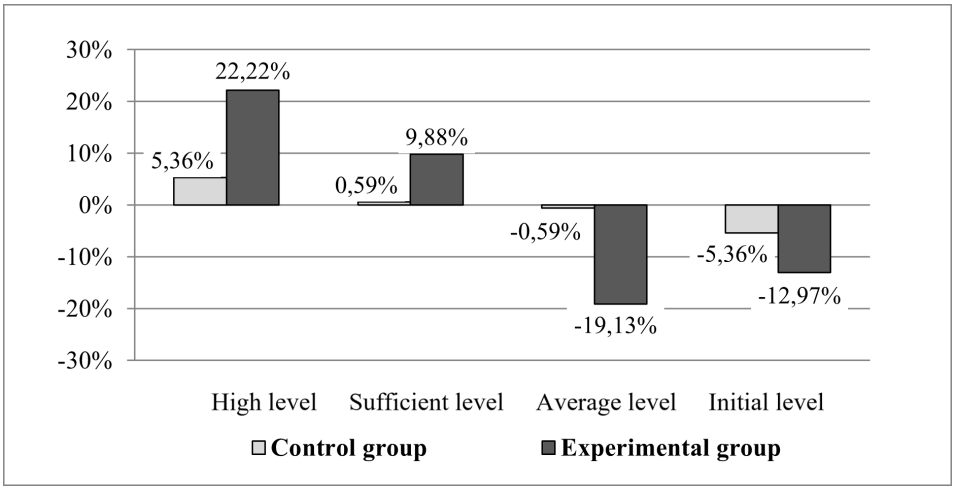
50 (CG)	12	24.00	19	40.00	17	34.00	1	2.00
55 (EG)	18	32.73	28	50.91	9	16.36	0	0

Figure 2. Histogram of the distribution of the CG and the EG high schoolers by the levels of their bioethical knowledge formedness at the formative stage of the experiment.



Based on the generalization of the results of the experimental work, it was found that in the EG the number of the 7-9th graders who reached a high level of bioethical knowledge formedness increased by 13.53 % (from 12.94 % to 26.47 %), and in the CG only by 1.95 % (from 16.96 % to 18.91 %). The number of high schoolers with a sufficient level of bioethical knowledge formedness in the EG increased by 11.11 % (from 33.88 % to 44.99 %), in the CG only by 3.22 % (from 33.11 % to 36.33 %). The number of high schoolers with an average level of bioethical knowledge formedness in the EG decreased by 9.77 % (from 35.80 % to 26.03 %), and in the CG it increased by 4.9 % (from 34.32 % to 39.22 %). In our opinion, this is because some high schoolers with an initial level of bioethical knowledge formedness moved to the average level. The number of high schoolers with an initial level of bioethical knowledge formedness after the experiment in the EG decreased by 14.88 % (from 17.38 % to 2.50 %), in the CG by 10.07 % (from 15.61 % to 5.54 %) (Figure 3). This proves the effectiveness of the methodology developed in the research for the formation of bioethical knowledge in adolescents during their biology lessons.

Figure 3. Dynamics of the levels of bioethical knowledge formedness in the 7th – 9th-grade high schoolers at the ascertaining and formative stages of the pedagogical experiment.



To confirm the validity of the results of the pedagogical experiment, their statistical analysis was carried out using Pearson's criterion ($\chi 2$). As a result of comparing the value of Pearson's criterion ($\chi 2$) at the ascertaining and formative stages of the pedagogical experiment with the critical value (9.488), the following conclusions were drawn:

– at the formative stage of the experiment, the empirical value of Pearson's criterion ($\chi 2$) was 1.23. At the same time, the inequality $1.23 < 9.488$ is true. Therefore, the EG and the CG belong to the same general population, i.e., there is no significant difference in the levels of bioethical knowledge formedness in adolescents;

– after the formative stage of the pedagogical experiment, the empirical value of the Pearson's criterion ($\chi 2$) was 11.19, i.e. the inequality $11.19 > 9.488$ is true. Therefore, the difference in the levels of bioethical knowledge formedness in the EG and the CG adolescents is a consequence of implementing the developed methodology.

Discussion

As a result of the analysis and generalization of the results of experimental research, it was found that the levels of formation of bioethical knowledge in students of different grades differ. Based on the analysis of the results of the formative stage of the pedagogical experiment, it was concluded that the number of high schoolers with a high level of bioethical knowledge formedness significantly increased in the EG compared to the CG. Most high

schoolers with a high level of bioethical knowledge formedness are in the 9th grades. In our opinion, this is because at the age of 15, adolescents are more emotionally stable, able to perceive themselves and their surroundings adequately, and able to distinguish between the main categories of morality and adhere to the moral principles of life. These age-specific characteristics of adolescents positively impact the perception of bioethical educational material. We associate the lower percentage of high schoolers with a high level of bioethical knowledge among the 7th-grade high schoolers with the fact that at 13, there is a transition from concrete to logical thinking. At this age, it is difficult for adolescents to establish analogies between the general laws of living nature and the categories of morality, and to make moral choices. In our opinion, the reason for the small number of high schoolers with a high level of bioethical knowledge formedness in the 8th grades at 14 is the culmination of the adolescent crisis, manifestations of which are emotional instability, negativism, egocentrism, protest against social norms and rules. At this age, the most pronounced is the reluctance to learn.

Thus, the formation of bioethical knowledge depends not only on the pedagogical flow but also on the psychological characteristics of high schoolers at different stages of adolescence. Considering this, it is necessary to purposefully form bioethical knowledge in the 9th grade. During this age period, the crisis of adolescence ends, self-awareness and awareness of the moral norms of society are actively developing, the teenager is able to distinguish between the moral categories of "good" and "evil", acquires personal qualities and skills that are necessary for adult life. Since it is difficult for 7th grade students to establish analogies and make moral choices, it is advisable to highlight only individual bioethical aspects during biology lessons, in particular, to draw attention to the problem of the value of nature, to form a humane attitude towards animals. The least effective method of forming bioethical knowledge during biology lessons in the 8th grade turned out to be. This necessitates further study of the problem under investigation and the development of teaching methods that will ensure the formation of bioethical knowledge and value orientations of students during the culminating period of the adolescent crisis.

The procedure for organizing the study and the topic of the article were previously agreed with the Committee on compliance with Academic Integrity and Ethics of the Khmelnytskyi National University (Khmelnytskyi, Ukraine). Also this study followed the regulations of the World Medical Association Declaration of Helsinki. Informed consent was received from all participants who took part in this study.

Conclusions

Based on the analysis of scientific works, it has been found that the formation of bioethical knowledge involves content-based (assimilation of knowledge about moral values and norms of behavior) and procedural (use of teaching methods and technologies aimed at transforming the objectively necessary into subjectively significant) aspects. Taking these aspects into account, a methodology for forming bioethical knowledge in high schoolers during their biology education has been developed, which involves the actualization of bioethical aspects in the content of the educational material and the use of verbal, visual, interactive, problem-based, and project-based teaching methods.

The study highlighted the results of experimental work conducted to test the effectiveness of the methodology for the formation of bioethical knowledge in adolescents during biology lessons. A pedagogical experiment was conducted to determine the effectiveness of the methodology. Students of secondary education institutions of adolescent age (grades 7-9) participated in the experiment. Control and experimental groups of students were selected for the experiment. The experimental groups implemented the methodology for the formation of bioethical knowledge during biology lessons, the features of which were the actualization of ethical aspects in the content of the educational material and the combination of different teaching methods. To actualize bioethical aspects, the content of the educational material in biology was supplemented with information that provides the opportunity to establish analogies between the laws of living nature and the categories of morality, and cards with ethical dilemmas were also developed.

As a result of generalizing the results of the study, it was found that in the experimental groups the percentage of students with a high level of formation of bioethical knowledge increased, and with a low level - decreased. The bioethical knowledge of students in the experimental groups was more conscious. The use of various teaching methods in implementing the methodology for forming bioethical knowledge contributed to the development of high schoolers' cognitive motives, the formation of conscious bioethical knowledge, emotional perception of living nature, and value attitudes towards it. The high schoolers acquired the ability to be guided in their activities by moral principles and to make environmentally appropriate decisions. The results of the pedagogical experiment confirmed the effectiveness of the methodology for forming bioethical knowledge in adolescents during their biology education.

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Conflict of Interest

The authors declare that there are no conflicts of interest.

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