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- 13.00.00 Pedagogika fanlari
- 13.00.01 Pedagogika nazariyasi. Pedagogik ta'limotlar tarixi
- 13.00.02 Ta'lim va tarbiya nazariyasi va metodikasi (sohalar bo'yicha)
- 13.00.03 Maxsus pedagogika
- 13.00.04 Jismoniy tarbiya va sport mashg'ulotlari nazariyasi va metodikasi
- 13.00.05 Kasb-hunar ta'limi nazariyasi va metodikasi
- 13.00.06 Elektron ta'lim nazariyasi va metodikasi (ta'lim sohaları va bosqichlari bo'yicha)
- 13.00.07 Ta'limda menejment
- 13.00.08 Maktabgacha ta'lim va tarbiya nazariyasi va metodikasi
- 13.00.09 Ijtimoiy pedagogika
- 07.00.00 Tarix fanlari
- 19.00.00 Psixologiya fanlari
- 01.00.00 Fizika-matematika fanlari
- 02.00.00 Kimyo fanlari
- 03.00.00 Biologiya fanlari
- 09.00.00 Falsafa fanlari
- 10.00.00 Filologiya fanlari
- 11.00.00 Geografiya fanlari

# M

# AKTABGACHA VA AKTAB TA'LIMI

Pedagogika, psixologiya fanlariga ixtisoslashgan ilmiy jurnal



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# METHODOLOGICAL FOUNDATIONS FOR DEVELOPING ENVIRONMENTAL EDUCATION THROUGH THE INTEGRATION OF CLIMATE CHANGE EDUCATION INTO BIOLOGY LESSONS IN GENERAL SECONDARY SCHOOLS

Abdurakhmanova Iqbolkhon Yulchiyevna

Academic lyceum of the Tashkent state medical university, biology teacher

ORCID: 0009-0007-7096-6635

**Abstract:** This article examines the methodological foundations of strengthening environmental education through the integration of climate change topics into biology lessons in general secondary schools. The study emphasizes the role of biology education in developing students' ecological awareness, fostering responsible attitudes toward nature, and enhancing their scientific understanding of environmental issues. Particular attention is given to the application of modern teaching approaches, interactive methods, and interdisciplinary integration in explaining climate change-related concepts. The article also highlights practical strategies for promoting environmental culture and sustainable thinking among students through effective classroom instruction.

**Key words:** climate change, biology education, environmental education, ecological awareness, sustainable development, interdisciplinary integration, interactive teaching methods, environmental culture, general secondary schools, scientific worldview.

**Annotatsiya:** Mazkur maqolada umumiy o'rta ta'lim maktablari biologiya darslariga iqlim o'zgarishi mavzularini integratsiya qilish orqali ekologik ta'limni kuchaytirishning metodologik asoslari yoritilgan. Tadqiqotda biologiya ta'limining o'quvchilarda ekologik ongni shakllantirish, tabiatga mas'uliyatli munosabatni rivojlantirish hamda ekologik muammolar haqidagi ilmiy tushunchalarni kengaytirishdagi o'rni tahlil qilingan. Iqlim o'zgarishi bilan bog'liq masalalarni tushuntirishda zamonaviy pedagogik yondashuvlar, interfaol metodlar va fanlararo integratsiyadan foydalanish masalalariga alohida e'tibor qaratilgan. Shuningdek, maqolada samarali ta'lim jarayoni orqali o'quvchilarda ekologik madaniyat va barqaror fikrlashni shakllantirishning amaliy yo'llari yoritilgan.

**Kalit so'zlar:** Iqlim o'zgarishi, biologiya ta'limi, ekologik ta'lim, ekologik ong, barqaror rivojlanish, fanlararo integratsiya, interfaol ta'lim metodlari, ekologik madaniyat, umumiy o'rta ta'lim maktablari, ilmiy dunyoqarash.

**Аннотация:** В данной статье рассматриваются методологические основы усиления экологического образования посредством интеграции тем изменения климата в уроки биологии общеобразовательных школ. В исследовании подчёркивается роль биологического образования в формировании экологического сознания учащихся, развитии ответственного отношения к природе и расширении научного понимания экологических проблем. Особое внимание уделяется использованию современных педагогических подходов, интерактивных методов и междисциплинарной интеграции при изучении вопросов, связанных с изменением климата. Также в статье освещаются практические пути формирования экологической культуры и устойчивого мышления учащихся посредством эффективной организации учебного процесса.

**Ключевые слова:** Изменение климата, биологическое образование, экологическое образование, экологическое сознание, устойчивое развитие, междисциплинарная интеграция, интерактивные методы обучения, экологическая культура, общеобразовательные школы, научное мировоззрение.



## INTRODUCTION

Today, climate change is considered one of the most serious global environmental challenges affecting natural ecosystems, biodiversity, agriculture, water resources, and human health. Rising temperatures, irregular precipitation, droughts, floods, and other extreme natural events demonstrate the urgent need for environmental awareness and sustainable action. In this context, education has become one of the most effective tools for preparing younger generations to understand environmental problems and participate in solving them. Many international researchers have emphasized the importance of integrating climate change education into school curricula. According to UNESCO (2021), climate change education helps learners develop the knowledge, values, skills, and responsible behaviors necessary for environmental protection and sustainable development. UNESCO also reported that only about half of national curricula worldwide include references to climate change, highlighting the need for stronger educational integration (UNESCO, 2021).

Jakubowski et al. (2021) highlighted that science education, especially biology and molecular biology, should include climate-related content because students need a scientific understanding of environmental changes and their consequences. The authors stressed that teachers have a professional responsibility to explain climate issues through subject-based learning and practical examples (Jakubowski et al., 2021). Similarly, Nepraš, Strejčková, and Kroufek (2022) found that climate change education in primary and secondary schools improves students' environmental attitudes, mitigation behaviors, and willingness to participate in ecological activities. Their systematic review confirmed that interdisciplinary and activity-based teaching methods increase the effectiveness of climate education (Nepraš et al., 2022). Local researchers in Uzbekistan have also paid attention to environmental education and the formation of ecological culture in general secondary schools. Scholars such as N. A. Muslimov (2019), Sh. S. Sharipov (2020), and R. H. Juraev (2021) emphasized that ecological education should be closely connected with natural science subjects, especially biology, because these subjects directly explain the relationship between humans and nature. Their studies support the idea that integrating climate change topics into biology lessons strengthens students' ecological worldview and environmental responsibility.

Biology lessons provide broad opportunities for explaining ecosystems, biodiversity loss, adaptation, environmental pollution, and the sustainable use of natural resources. Therefore, the integration of climate change education into biology classes is an important pedagogical direction for improving environmental education and developing students' ecological culture. This article focuses on the methodological foundations of integrating climate change education into biology lessons in general secondary schools and explores effective approaches to strengthening ecological education and environmental awareness among students.

## LITERATURE REVIEW

The problem of integrating climate change education into biology lessons has become one of the important directions in modern environmental pedagogy. Many international and local researchers emphasize that biology education plays a significant role in developing students' ecological awareness, environmental responsibility, and sustainable thinking. Since biology explains natural processes, ecosystem balance, biodiversity, and the relationship between living organisms and the environment, it provides broad opportunities for teaching climate change issues in a meaningful and practical way. According to UNESCO (2021), climate change education should be considered an essential component of education for sustainable development. The organization highlights that climate-related topics should not be taught separately but should be integrated into existing school subjects such as biology, geography, chemistry, and social sciences. This interdisciplinary approach helps students understand climate problems from different scientific perspectives and apply their knowledge to real-life environmental situations.

Anderson (2012) states that climate education becomes more effective when students are actively involved in the learning process through discussions, problem-solving tasks, project-based learning, and inquiry activities. Such methods improve critical thinking and encourage students to take personal responsibility for environmental protection. In biology lessons, these strategies can be applied through the study of biodiversity loss, ecosystem changes, and the effects of human activities on natural resources. Monroe et al. (2019) also emphasize that the success of climate change education largely depends on teachers' methodological preparation and the use of student-centered teaching approaches. Their research shows that inquiry-based learning, field observations, laboratory experiments, and environmental projects help students better understand climate-related processes and strengthen long-term ecological awareness. The authors stress that climate education should not only explain problems but also guide students toward practical solutions and sustainable actions. Stevenson, Nicholls, and Whitehouse (2017) found that environmental education becomes more effective when students develop an emotional connection with nature. Their study shows that outdoor learning and

participation in local ecological projects significantly improve students' environmental attitudes and responsible behavior. This is especially relevant in biology teaching, where direct observation and practical interaction with natural systems support deeper understanding.

Wals (2015) argues that education for sustainable development should focus on responsible decision-making rather than the simple memorization of facts. He supports the use of interdisciplinary learning, problem-solving tasks, and active citizenship in climate education. His ideas confirm that biology lessons should encourage students to analyze environmental problems critically and seek sustainable solutions. Leal Filho et al. (2018) also underline the importance of climate literacy in school education. Their research shows that preparing students for climate adaptation requires early educational intervention and strong teacher preparation. They note that both global climate processes and local ecological risks should be included in school science education. In Uzbekistan, local researchers such as N. A. Muslimov (2019), Sh. S. Sharipov (2020), and R. H. Juraev (2021) have paid special attention to ecological education in general secondary schools. They emphasize that environmental education should be closely connected with natural science subjects, especially biology, because these subjects directly explain the interaction between humans and nature. They also note that ecological education should be based on national environmental problems such as water scarcity, desertification, air pollution, biodiversity loss, and the ecological consequences of the Aral Sea crisis.

Methodologically, scholars suggest that the integration of climate change education into biology lessons requires careful lesson planning, the selection of relevant teaching materials, and the use of interactive methods such as brainstorming, cluster techniques, Venn diagrams, debates, and project work. For example, while studying ecosystems, students can analyze how temperature changes affect food chains and species survival. During lessons on photosynthesis and respiration, teachers can explain the role of carbon dioxide in global warming and the importance of forests in climate regulation. Researchers also stress that students' ecological awareness should be assessed not only through theoretical tests but also through presentations, research tasks, field observations, reports, and participation in environmental activities. Such assessment methods allow teachers to evaluate both knowledge and practical environmental responsibility.

Thus, the analysis of scientific literature confirms that integrating climate change education into biology lessons creates favorable conditions for strengthening environmental education, developing students' scientific worldviews, and fostering sustainable environmental behavior. It also supports the broader goal of preparing environmentally responsible citizens capable of addressing future ecological challenges.

## RESEARCH METHODOLOGY

This study is based on the analysis of pedagogical, biological, and environmental education literature related to climate change education and its integration into school biology lessons. Both international and local scientific sources were examined to identify effective approaches to improving environmental education in general secondary schools. The research applied comparative analysis, content analysis, and observation methods. Comparative analysis was used to study the views of foreign and Uzbek scholars on climate change education and ecological learning. Content analysis helped examine biology curricula, textbooks, and teaching materials in order to determine how climate-related topics can be integrated into classroom instruction.

In addition, observations of teaching practices and interactive classroom methods such as discussions, project work, Venn diagrams, and problem-solving tasks were used to evaluate their role in developing students' ecological awareness. The study also considered local environmental problems, including water scarcity, biodiversity loss, and the Aral Sea crisis, as practical examples for improving climate education through biology lessons. The methodological approach of the research is aimed at identifying effective pedagogical conditions for strengthening environmental education and fostering sustainable ecological thinking among school students.

## ANALYSIS AND RESULTS

The analysis of scientific literature and classroom practice confirms that the integration of climate change education into biology lessons significantly improves students' ecological awareness, environmental responsibility, and sustainable thinking. Biology provides a strong academic basis for explaining the relationship between living organisms and the environment, ecosystem balance, biodiversity loss, and the influence of human activities on climate processes. According to UNESCO (2021), students achieve better learning outcomes when climate change is taught through existing school subjects rather than as an isolated topic. The report shows that interdisciplinary teaching helps learners understand climate-related problems more deeply and supports the development of responsible environmental behavior. This finding is especially relevant in biology lessons, where climate-related concepts can be naturally connected with ecosystems, adaptation,



photosynthesis, and food chains. Monroe et al. (2019) found that student-centered teaching methods such as inquiry-based learning, environmental projects, and field observations increase long-term ecological awareness. Their research demonstrates that active participation helps students not only understand environmental problems but also seek practical solutions. In this study, similar results were observed when students worked on local environmental case studies and participated in project-based learning activities.

Anderson (2012) also emphasizes that discussions, problem-solving tasks, and project work improve students' critical thinking and personal responsibility for nature conservation. During biology lessons, the use of brainstorming, Venn diagrams, debates, and ecological problem analysis helped students connect scientific theory with real environmental challenges. Special attention was given to local environmental issues such as water scarcity, desertification, biodiversity loss, and the ecological consequences of the Aral Sea crisis. Muslimov (2019) and Sharipov (2020) argue that ecological education becomes more meaningful when students study environmental problems directly related to their own region. The results of this research support this idea, as students showed stronger motivation and deeper understanding when local ecological examples were included in classroom discussions. Stevenson, Nicholls, and Whitehouse (2017) reported that outdoor learning and participation in local environmental activities improve students' emotional connection with nature and strengthen pro-environmental behavior. Similar observations were identified in this study, where practical activities and field observations increased students' interest in and responsibility toward environmental protection.

The analysis also revealed that traditional written tests are insufficient for evaluating ecological education effectively. Wals (2015) states that education for sustainable development should focus on practical decision-making and responsible action rather than the memorization of facts. Based on this idea, presentations, research assignments, observation reports, and participation in ecological projects were found to be more effective tools for assessing students' environmental competence. Thus, the results show that integrating climate change education into biology lessons creates strong conditions for improving environmental education in general secondary schools. Effective teacher preparation, interdisciplinary teaching, interactive methods, and the use of local ecological examples are the main factors supporting the formation of environmentally responsible and scientifically literate students. The findings of this study confirm that the integration of climate change education into biology lessons is not only a methodological necessity but also an effective pedagogical strategy for strengthening environmental education in general secondary schools. The results are consistent with the conclusions of UNESCO (2021), which emphasize that climate education becomes more effective when it is embedded within existing school subjects rather than taught separately. Biology, due to its direct connection with ecosystems, biodiversity, and environmental balance, provides a natural foundation for such integration.

The positive impact of student-centered teaching methods identified in this research also supports the work of Monroe et al. (2019), who found that inquiry-based learning, field observations, and environmental projects significantly improve students' long-term ecological awareness. In both studies, active participation was shown to be more effective than traditional lecture-based instruction because students were able to connect scientific concepts with real environmental problems and practical solutions. Similarly, Anderson (2012) argued that discussions, problem-solving tasks, and project work help students develop critical thinking and personal responsibility. The present study confirms this view, especially in biology lessons, where interactive methods such as Venn diagrams, brainstorming, and ecological case analysis increased student engagement and understanding. This suggests that climate education should focus not only on knowledge transfer but also on the development of analytical and decision-making skills.

The importance of local environmental examples observed in this research is strongly supported by Muslimov (2019), Sharipov (2020), and Juraev (2021), who state that ecological education becomes more effective when students study problems related to their own living environment. The use of topics such as water scarcity, desertification, and the Aral Sea crisis allowed students to understand climate change as a direct social and ecological issue rather than a distant global concept. This local relevance increases both motivation and environmental responsibility. The study also agrees with Stevenson, Nicholls, and Whitehouse (2017), who emphasized the role of an emotional connection with nature in shaping sustainable behavior. Outdoor learning and participation in environmental activities were found to strengthen students' ecological values and encourage the active protection of natural resources. This shows that effective biology teaching should combine scientific explanation with practical environmental experience.

Regarding assessment, the results support Wals (2015), who criticized traditional testing as insufficient for measuring ecological competence. This research confirms that practical assignments, presentations, and project-based evaluation provide a more comprehensive picture of students' environmental awareness and responsible behavior. Such assessment methods reflect not only cognitive understanding but also attitudes and real-life application. Overall, the discussion shows that the successful modernization of environmental education depends on several interconnected factors: interdisciplinary curriculum design, teachers' methodological

competence, interactive learning strategies, local environmental context, and practical assessment methods. These findings demonstrate that biology education can serve as a powerful platform for preparing students to respond responsibly to climate change and future ecological challenges.

## CONCLUSION

The study confirms that integrating climate change education into biology lessons is an effective approach to modernizing the content of environmental education in general secondary schools. Biology, as a fundamental natural science subject, provides broad opportunities for explaining ecological balance, biodiversity, ecosystem changes, and the impact of human activities on the environment. Through this integration, students develop scientific understanding, environmental awareness, and a sense of personal responsibility toward nature. The research findings show that climate change education becomes more effective when it is supported by interdisciplinary connections, interactive teaching methods, and practical environmental examples. Student-centered approaches such as project-based learning, field observations, discussions, problem-solving tasks, and visual methods help learners better understand ecological issues and encourage sustainable behavior. These methods also strengthen critical thinking and improve students' participation in environmental protection activities.

Special importance should be given to the use of local environmental problems, including water scarcity, desertification, biodiversity loss, and the ecological consequences of the Aral Sea crisis. Teaching climate change through local examples makes environmental education more relevant, understandable, and meaningful for students. It allows them to connect global climate challenges with their own social and natural surroundings. Based on the results of the study, the following recommendations are proposed: Climate change education should be systematically integrated into biology curricula at all levels of general secondary education.

Teachers should widely apply interactive, inquiry-based, and student-centered teaching methods to improve ecological learning outcomes. Biology textbooks and educational resources should be enriched with local environmental case studies and climate-related examples. Teacher training and professional development programs should include methodological preparation for teaching climate change and environmental sustainability. Student assessment should combine theoretical knowledge with practical activities such as environmental projects, presentations, observations, and research tasks. The implementation of these recommendations will contribute to the formation of environmentally responsible, scientifically literate, and socially active students who are capable of supporting sustainable development and responding effectively to future environmental challenges.

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- 13.00.00 Pedagogika fanlari
  - 13.00.01 Pedagogika nazariyasi. Pedagogik ta'limotlar tarixi
  - 13.00.02 Ta'lim va tarbiya nazariyasi va metodikasi (sohalar bo'yicha)
  - 13.00.03 Maxsus pedagogika
  - 13.00.04 Jismoniy tarbiya va sport mashg'ulotlari nazariyasi va metodikasi
  - 13.00.05 Kasb-hunar ta'limi nazariyasi va metodikasi
  - 13.00.06 Elektron ta'lim nazariyasi va metodikasi (ta'lim sohaları va bosqichlari bo'yicha)
  - 13.00.07 Ta'limda menejment
  - 13.00.08 Maktabgacha ta'lim va tarbiya nazariyasi va metodikasi
  - 13.00.09 Ijtimoiy pedagogika
  - 07.00.00 Tarix fanlari
  - 19.00.00 Psixologiya fanlari
  - 01.00.00 Fizika-matematika fanlari
  - 02.00.00 Kimyo fanlari
  - 03.00.00 Biologiya fanlari
  - 09.00.00 Falsafa fanlari
  - 10.00.00 Filologiya fanlari
  - 11.00.00 Geografiya fanlari



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**Ingliz tili muharriri:** Murod Xoliyorov

**Musahhih:** Alibek Zokirov

**Sahifalovchi va dizayner:** Iskandar Islomov

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