



**INNOVATIVE PEDAGOGICAL TECHNOLOGIES AND
METHODOLOGICAL FOUNDATIONS FOR DEVELOPING STUDENTS'
ENVIRONMENTAL COMPETENCE IN THE PROCESS OF
ENVIRONMENTAL EDUCATION**

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Abstract

This article examines the theoretical and methodological foundations of developing university students' environmental competence, the pedagogical integration of innovative teaching technologies, and assessment criteria. Environmental competence is conceptualized as an integration of environmental knowledge, systems thinking, values, evidence-informed decision-making, and reflective responsibility. A five-stage instructional model is proposed, combining problem-based, project-based, and inquiry-based learning, STEAM, and digital environmental monitoring. The paper offers a conceptual and methodological framework; it does not claim empirical intervention outcomes or statistical effectiveness. The paper also considers ways to integrate Uzbekistan's environmental education legislation into university teaching.

Keywords: Environmental education, environmental competence, sustainability, GreenComp, systems thinking, project-based learning, environmental monitoring.

Introduction

**EKOLOGIK TA'LIM JARAYONIDA TALABALARNING EKOLOGIK
KOMPETENTLIGINI RIVOJLANTIRISHNING INNOVATSION
PEDAGOGIK TEXNOLOGIYALARI VA METODIK ASOSLARI**

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ANNOTATSIYA

Mazkur maqolada oliy ta'limda ekologik kompetentlikni rivojlantirishning nazariy-metodologik asoslari, innovatsion pedagogik texnologiyalarni didaktik integratsiyalash imkoniyatlari va natijalarni baholash mezonlari tahlil qilinadi.

Ekologik kompetentlik ekologik bilim, tizimli tafakkur, qadriy munosabat, amaliy qaror qabul qilish hamda refleksiv mas'uliyat birligi sifatida talqin etiladi. Muammoli ta'lim, loyiha asosida o'qitish, tadqiqotga yo'naltirilgan faoliyat, STEAM va raqamli ekologik monitoringga tayangan besh bosqichli metodik model taklif etiladi. Taklif etilgan modelning pedagogik qo'llanishi, kuzatiladigan indikatorlari va baholash rubrikasi asoslanadi. Maqola nazariy-metodik xarakterga ega bo'lib, unda tajriba-sinov natijalari yoki statistik samaradorlik ko'rsatkichlari da'vo qilinmaydi. Shuningdek, O'zbekiston Respublikasining ekologik ta'limga oid normativ-huquqiy hujjatlarini o'quv jarayoniga integratsiyalashning metodik imkoniyatlari tahlil qilinadi.

Kalit so'zlar: ekologik ta'lim, ekologik kompetentlik, barqaror rivojlanish, GreenComp, tizimli tafakkur, muammoli ta'lim, loyiha metodi, STEAM, ekologik monitoring, refleksiv baholash.

АННОТАЦИЯ

В статье анализируются теоретико-методологические основы формирования экологической компетентности студентов в высшем образовании, возможности интеграции инновационных педагогических технологий и критерии оценивания результатов. Экологическая компетентность рассматривается как единство знаний, системного мышления, ценностных установок, практического принятия решений и рефлексивной ответственности. Предложена пятиэтапная методическая модель, объединяющая проблемное, проектное и исследовательское обучение, STEAM и цифровой экологический мониторинг. Работа носит теоретико-методический характер; эмпирические результаты не заявляются. Также рассмотрены методические возможности интеграции нормативно-правовых основ экологического образования Узбекистана.

Ключевые слова: экологическое образование, экологическая компетентность, устойчивое развитие, системное мышление, проектное обучение, экологический мониторинг.

INTRODUCTION

Issues such as climate change, biodiversity loss, water scarcity, soil degradation, and waste management necessitate a re-evaluation of the content of environmental education. In higher education, limiting environmental literacy to the mere memorization of concepts fails to adequately develop students' ability to make informed decisions in complex environmental situations. Therefore, linking knowledge to real-world regional issues, verifying evidence, and evaluating practical activities are of critical importance in environmental education.

The UN Sustainable Development Goals—specifically Target 4.7—establish the necessity of integrating education for sustainable development into the educational process [9]. UNESCO's document "Education for Sustainable Development: A Roadmap" highlights educational content, the learning environment, educator capacity, and local community engagement as interconnected areas [10]. These conceptual foundations necessitate a shift in environmental education from a model based on information delivery to one focused on action. The legal foundation for environmental education in the Republic of Uzbekistan rests on the Law "On Nature Protection" (December 9, 1992, No. 754-XII) and the Law "On Education" (September 23, 2020, No. ORQ-637). The former establishes general legal principles for environmental protection, while the latter outlines the fundamentals for organizing educational activities. In this context, developing environmental competence requires integrating environmental knowledge with legal awareness, a sense of responsibility, and practical behavior [1; 2]. The Concept for the Development of Environmental Education in the Republic of Uzbekistan, approved by the Cabinet of Ministers Resolution No. 434 dated May 27, 2019, serves as a crucial programmatic framework aimed at systematically organizing environmental education and fostering an environmental culture [3]. Meanwhile, the Concept on Environmental Protection, approved by the Presidential Decree No. PF-5863 dated October 30, 2019, highlights the strategic importance of issues concerning environmental safety and the conservation of natural resources [4]. When applying these documents to higher education didactics, it is advisable to offer students project assignments involving case studies based on environmental legislation, regional environmental issues, and public participation.

The aim of the study is to theoretically develop a methodological model—based on the integration of innovative pedagogical technologies—to foster environmental

competence among higher education students, and to define the indicators for its assessment. The research objectives include: defining the components of environmental competence; conducting a comparative analysis of effective didactic approaches; designing a sequence of practical activities; and proposing tools for criterion-based assessment of results.

Regulatory and legal updates over the past five years have reinforced the need to redesign the content of environmental education based on a competency-based approach. Notably, the Concept for Raising the Population's Environmental Culture until 2030—approved by the President's Resolution No. PQ-184 dated May 15, 2025—identifies the development of the younger generation's environmental knowledge, awareness, and culture, as well as the improvement of the personnel training system, as priority tasks [5]. Resolution No. PQ-110, dated March 25, 2026, aims to strengthen the integration of environmental education, science, and advocacy—as well as the training of specialists equipped with practical skills—within the framework of the "Eco-culture" nationwide project [6]. These documents serve as a methodological basis for assessing students' environmental competence not merely through theoretical knowledge, but through the analysis of real-world environmental situations and responsible practical actions.

LITERATURE REVIEW AND METHODOLOGY

The European Commission's GreenComp framework outlines sustainability competencies across four interconnected areas: embodying sustainability values, embracing complexity in sustainability, envisioning sustainable futures, and acting for sustainability [11]. This approach provides a basis for measuring environmental education outcomes not only through test-based knowledge but also through situational analysis, the assessment of future scenarios, and collective action.

UNESCO's recommendations on Education for Sustainable Development emphasize the integration of cognitive, socio-emotional, and behavioral components [12]. Kolb's experiential learning model helps explain the practical study of environmental issues through the stages of concrete experience, reflective observation, abstract conceptualization, and active experimentation [13]. These approaches complement one another, yet they require adaptation to the specific subject, region, and students' level of preparation.



In local scientific literature, A. Ergashev elucidates the theoretical foundations of ecosystems, natural environmental factors, and anthropogenic impacts [15; 16]. The educational literature on ecology and environmental protection authored by P.S. Sultonov and B.P. Ahmedov [17] serves as a methodological resource for linking ecological knowledge with practical nature conservation tasks. Harmonizing these local approaches with GreenComp and UNESCO recommendations enables the adaptation of ecological case studies, regional monitoring, and student projects to the national context.

The article employs methods of theoretical analysis, comparison, conceptual modeling, and pedagogical design. The proposed methodological model represents an original synthesis, the effectiveness of which requires verification through subsequent empirical research. Key criteria for the analysis included the scientific reliability of the ecological content, active student participation, interdisciplinary connections, evidence-based conclusions, and transparency of assessment.

SCIENTIFIC AND METHODOLOGICAL SIGNIFICANCE OF REGULATORY DOCUMENTS (2021–2026)

The President's Decree No. PF-81, dated May 31, 2023, is aimed at transforming governance in the sphere of ecology and environmental protection [7]. This document enables the linking of topics such as institutional responsibility in environmental education, environmental oversight, and the rational use of natural resources with practical case studies. Presidential Decree No. PF-16, dated January 30, 2025, reflects the priority tasks of the "Uzbekistan–2030" Strategy regarding environmental protection and the green economy [8]. When integrating this into the educational process, project assignments can be developed focusing on indicators such as carbon footprint reduction, renewable energy, resource efficiency, and environmental performance.

Resolution No. PQ-184 outlines the objectives for fostering environmental culture and defines directions for the development of education, personnel training, and scientific research [5]. Meanwhile, Resolution No. PQ-110 further clarifies the organizational and professional training aspects of environmental education [6]. Therefore, it is proposed that the model for developing students' environmental competence be designed according to the following sequence: identifying regulatory requirements → selecting a local environmental issue → gathering scientific evidence

→ evaluating alternative solutions based on environmental and social criteria → presenting the project outcome → reflection. This sequence represents a proposed methodological approach and should not be interpreted as a direct regulatory requirement.

INTEGRATING REGULATORY AND LEGAL FRAMEWORKS INTO THE EDUCATIONAL PROCESS

Working with regulatory and legal documents serves as a didactic tool for elevating students' environmental literacy to the level of practical competence. A three-stage approach is proposed: (1) identifying the environmental principle and requirement within the document; (2) applying this requirement to the local environmental context and analyzing the evidence; and (3) developing a solution that is legally, scientifically, and socially grounded. For instance, in a university waste-sorting project, students observe an environmental issue, compare the positions of stakeholders, and formulate practical recommendations. During this process, a distinction must be made between interpreting legal texts and exercising the authority to apply current legislation, and legal conclusions must be verified against official sources.

ANALYSIS AND DISCUSSION OF RESULTS

A structural model of environmental competence. A student's environmental competence can be characterized through five interconnected components: (1) cognitive — explaining ecosystems, material cycling, anthropogenic pressure, and environmental risks; (2) analytical — collecting and comparing data and identifying uncertainties; (3) axiological — fostering a responsible attitude toward nature and recognizing conflicts of interest; (4) action-oriented — planning solutions for environmental problems; (5) reflexive — evaluating and improving upon the consequences of one's decisions.

Didactic functions of innovative technologies. Problem-based learning places the student in a situation where multiple alternative solutions exist. Project-based learning focuses on creating a final product—such as a waste-sorting system design or a map of campus water consumption. Inquiry-based learning integrates hypothesis formulation, sampling, observation, data analysis, and drawing conclusions. STEAM connects environmental issues with natural sciences, technology, engineering, and mathematical modeling. Digital tools facilitate data collection and visualization,

though factors such as the calibration of measuring instruments, data source quality, and personal data security require oversight.

The proposed five-stage methodological model is based on the following logic: diagnosis → problem situation → research and design → practical solution → reflection and re-evaluation. In the first stage, initial knowledge and environmental perspectives are identified. In the second stage, a local environmental problem is defined based on evidence. In the third stage, students work in small groups to gather information, model cause-and-effect relationships, and compare alternatives. In the fourth stage, a real-world or simulated project is developed. In the fifth stage, the project is evaluated against specific criteria, and limitations and next steps are noted.

Table 1. Model matrix for developing and assessing environmental competence.

Component	Learning Activities	Observable indicator
Cognitive	Environmental case study analysis	Scientifically explains cause-and-effect relationships
Analytical	Analysis of water or air quality data	Draws well-founded conclusions from tables and graphs
Axiological	Discussion of environmental dilemmas	Considers the socio-ecological consequences of decisions
Activity-based	Campus environmental project	Develops measurable goals and an actionable plan
Reflexive	Portfolio and peer assessment	Identifies errors and revises the solution

Sample practical exercise: “Assessing the municipal waste stream on the university campus.” Over the course of one week, students inventory waste by type in designated areas; maintain a standardized observation log; calculate total volumes and compositional proportions; map key waste generation points; and compare two alternative waste-sorting solutions based on cost, organizational feasibility, and expected environmental impact. Ultimately, each group presents an evidence-based brief report, an infographic, and an implementation plan. Data collected during this assignment are intended for educational purposes; separate validation would be required to interpret the aggregated results as real-world monitoring data.

Assessment criteria. It is recommended that each component be evaluated using a 0–3 point analytical rubric: 0 — no evidence; 1 — partial, based on instructions; 2 — largely independent and scientifically grounded; 3 — independent, coherent, and

characterized by critical analysis and well-founded proposals for improvement. A total score of 0–15 is derived from the five components. This scale is a proposed methodological tool; it cannot be considered a standardized diagnostic instrument without prior testing for reliability and validity. To evaluate methodological effectiveness in the future, it is advisable to employ a combination of initial and final diagnostics, environmental case studies, project deliverables, and reflective portfolios. Comparisons must take into account the groups' baseline preparation, the teacher factor, the duration of instruction, and resource availability. Relying solely on self-assessment results may not fully reflect the actual practical level of competence. Methodological limitations. The mere use of digital technologies does not guarantee an increase in environmental competence. Safety, measurement errors, seasonality, and local environmental conditions must be considered during laboratory and field observations. Furthermore, the economic and social implications of environmental solutions for various social groups need to be discussed. Therefore, the choice of technology must always be aligned with learning outcomes and assessment criteria. To align regulatory and legal content with learning outcomes, it is recommended to integrate environmental case studies, document analysis, regional monitoring, and project presentations into a unified assessment system. In this context, the accuracy of environmental knowledge, the appropriate use of the legal framework, the reliability of data, the feasibility of the solution, and reflection are evaluated as distinct indicators. This proposal serves as a theoretical-methodological recommendation, the effectiveness of which requires verification through experimental testing.

A practical approach to linking regulatory legal documents with the competency-based model is to define specific learning outcomes for each session. For instance, a student explains the aspect of the concept outlined in Resolution No. PQ-184 regarding environmental culture (knowledge acquisition), observes waste flows on the university campus (research), develops a resource-saving plan (design), and evaluates its implementation based on evidence (reflection). The assessment criteria include the correct interpretation of the regulatory source, data reliability, and the ecological soundness and practical feasibility of the solution. The effectiveness of these criteria must be verified through specific empirical testing.

CONCLUSION

Developing environmental competence extends beyond the mere transmission of environmental knowledge; it requires a holistic didactic process that integrates systems thinking, evidence-based analysis, responsible decision-making, and practical environmental activity. GreenComp and the principles of education for sustainable development help establish the conceptual framework for this process. The targeted integration of problem-based learning, the project method, inquiry-based activities, STEAM, and digital monitoring enables students to work on real-world environmental issues.

The proposed five-stage model and indicator matrix can serve as a methodological basis for designing courses on "Fundamentals of Ecology" and related disciplines in higher education. Future research should focus on testing the model across various fields of study and regions, determining the reliability of the assessment rubric, and examining the long-term sustainability of the educational outcomes.

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