DOI:10.59787/2413-5488-2025-50-2-94-105

**[1]Nazerke Maratkyzy, [1]Anargul Sharipkhanova, [2]Sholpan Abilova, [2]Aiman Karabalayeva**

*[1]Sarsen Amanzholov East Kazakhstan University, Ust-Kamenogorsk, Kazakhstan*
*[2] Astana International University, Astana, Kazakhstan*

# INTEGRATED MODEL FOR DEVELOPING ENVIRONMENTAL COMPETENCE: SCIENTIFIC FOUNDATIONS, TECHNOLOGIES, AND REFLECTION

**Abstract:** The article is devoted to the development, testing, and evaluation of an integrated model for developing environmental competence in students at higher education institutions. The model is based on a comprehensive approach that includes cognitive, axiological, and practical components and combines theoretical, practice-oriented, and reflective blocks. This ensures the holistic formation of environmental knowledge, value orientations, and practical skills necessary for solving sustainable development tasks in students. The model was tested at the Sarsen Amanzholov East Kazakhstan University with the participation of 88 students divided into control and experimental groups. Quantitative and qualitative methods were used to evaluate its effectiveness: testing, questionnaires, observation, and expert assessment. The results showed a significant increase in the level of environmental competence in the experimental group, especially in the axiological and practical components. The developed model has proven its effectiveness and can be implemented in educational programs for training specialists in the fields of ecology, biology, and pedagogy, contributing to the formation of environmentally responsible and professionally competent personnel.

**Keywords:** environmental competence, cognitive component, axiological component, practical component, sustainable development, educational model, environmental education.

## Introduction.

In the context of rapid technological progress, globalization processes, and growing environmental threats, the higher education system faces the urgent task of training a new generation of specialists with environmental competence. Education is increasingly seen as a key factor in sustainable development, capable of shaping a responsible attitude toward the environment and stimulating behavioral change in society (Liulenko & Podzerei, 2022; Dlimbetova et al., 2015).

Contemporary environmental challenges such as climate change, biodiversity loss, and pollution of water, soil, and air resources, require future specialists to have not only fundamental knowledge, but also advanced practical skills, the ability to think in an interdisciplinary manner, and values aimed at finding and implementing sustainable solutions (Stagl, 2017; Özkan et al., 2024). In this context, environmental competence is defined as an integrative personal quality that includes knowledge, skills, values, and a readiness to take practical action to protect the environment (Karter, 2019; Klochko & Fedorets, 2023).

The formation of environmental competence is becoming an integral part of the training of specialists, regardless of their professional profile. This requires the introduction of scientifically based educational models that combine cognitive, practical, and reflective components. The development of such models involves the use of modern techniques, including environmental modeling, eco-trails, visualization of the social environment through eco-mapping, and participation in real projects (Jørgensen, 2008; Zameliuk, 2020; McKay et

al., 2022). This article aims to present an integrated model for the formation of students' environmental competence, which combines theoretical training, practical implementation, and reflective methods. Particular attention is paid to involving students in project activities and developing their skills in analysis, decision-making, and sustainable behavior.

The purpose of the study is to substantiate the scientific and methodological foundations of the proposed model, demonstrate its structure, and characterize the results of its testing in the university educational environment. The authors seek to show how a comprehensive and interdisciplinary approach to the formation of environmental competence contributes to the training of professionally competent and environmentally responsible specialists who are ready to solve sustainable development tasks.

**Methods and organization of research.**

The research methodology was based on a comprehensive approach that included elements of systems analysis, interdisciplinary interaction, and pedagogical diagnostics. The main objective of the study was to develop, test, and evaluate a model for the formation of environmental competence aimed at training specialists capable of effectively solving modern environmental problems. The research was based on theoretical approaches presented in the works of Ponomarova (2018), Palshkova (2003), Sotska and Kuzmenko (2019), as well as on contemporary aspects of environmental education proposed by Vdovenko (2022). This provided a scientific basis for the development of a methodology that considers the cognitive, axiological, and practical components of environmental competence.

The research methodology consisted of three stages. At the analytical stage, an in-depth analysis of existing models for the formation of environmental competence and their effectiveness was carried out. This process was based on the theoretical and methodological principles proposed by Palshkova (2003), who focused on the professional training of teachers in the context of environmental education. Various concepts and approaches were studied, including models that integrate theory, practice, and reflection. This stage made it possible to identify the key elements necessary for the formation of competence: the cognitive component, the axiological component, and the practical component.

During the design phase, a model for developing environmental competence was developed, which included three interrelated blocks: theoretical, practical, and reflective. The model was based on Vdovenko (2022) recommendations on environmental education. As part of the cognitive component, the model included interactive lectures and multimedia materials aimed at forming basic knowledge about environmental problems, the principles of sustainable development, and ways to solve them. This component contributed to the development of analytical thinking and the ability to apply theoretical knowledge in practice. The axiological component was focused on forming values of sustainable development, environmental responsibility, and a conscious attitude toward the environment. To this end, reflective methods were used, including discussions, training sessions, and essay writing aimed at developing students' values. The practical component included real-world tasks such as environmental monitoring, developing projects for the conservation of natural resources, and using digital technologies (e.g., GIS platforms). This component helped strengthen students' ability to apply their knowledge in real-world situations and develop innovative environmental solutions.

The developed model was tested during the experimental stage. The study involved 88 students from Sarsen Amanzholov East Kazakhstan University majoring in Biology and Natural Sciences and Pedagogical Biology. The participants were divided into control and experimental groups, which was in line with Palshkova (2003) recommendations for organizing a pedagogical experiment. The control group was taught according to the standard educational program, while the experimental group used the developed model, which simultaneously focused on the cognitive, axiological, and practical aspects of competence.

Both quantitative and qualitative methods were used to collect data. Testing was used to assess the level of students' environmental competence before and after the model was tested. As part of the cognitive component, students' basic knowledge related to environmental problems and their solutions was analyzed. Questionnaires completed by students and teachers provided data on satisfaction with the educational process and identified the strengths and weaknesses of the model, including the formation of values within the axiological component. Observation of students' work made it possible to analyze their involvement and level of practical skills application, which is especially important for assessing the practical component. Expert assessment methods were used to analyze the quality of students' performance of practical tasks and projects, which also made it possible to assess the formation of cognitive and practical competencies.

The data obtained was processed using quantitative and qualitative analysis. Quantitative analysis included mathematical processing of test and questionnaire results, which made it possible to identify the dynamics of changes in the cognitive, axiological, and practical components of competence. Qualitative analysis included the study of students' reflective reports and teachers' observations, which allowed for a deeper understanding of the process of forming environmental knowledge, values, and skills. A comparative analysis of the control and experimental groups showed a significant improvement in all components of environmental competence among students who studied according to the proposed model.

Thus, the methodology combined traditional and innovative approaches, which made it possible to create a model that ensures the comprehensive development of the cognitive, axiological, and practical components of environmental competence in students. The integration of theory, practice, and reflection into the educational process contributes not only to the development of professional knowledge and skills but also to the formation of value orientations necessary for sustainable development. This makes the proposed model promising for further implementation in educational programs.

**Research results and their discussion.**

The development of environmental competence is becoming one of the key tasks of modern education in the context of sustainable development. Scientific literature highlights the importance of integrating theoretical knowledge, practical skills, and reflective thinking in the process of environmental education. Liulenko and Podzerei (2022) emphasizes that environmental competence is a fundamental component of education for sustainable development. The authors view environmental competence as a set of knowledge, skills, and values that contribute to awareness of environmental problems and participation in their solution. Their work highlights the need to implement environmental approaches at all levels of the educational process.

Pedersen and Bang (2015) proposed a dialectical ecological-social model in which the development of competence is viewed through the prism of the interaction between the individual and the environment. Their research emphasizes the importance of a subject-oriented approach to learning, which allows for the development of environmental awareness and critical thinking. Stagl (2017) justifies the importance of ecological economics as an integrative approach that combines interdisciplinary knowledge and methods. According to the author, ecological economics forms the basis for sustainable education that promotes decision-making that takes environmental factors into account. Ogbu (1981) proposes a cultural-ecological approach to competence formation. The author focuses on cultural aspects and emphasizes that understanding of environmental issues must be adapted to the cultural context of learners.

Karter (2019) proposes an ecology-oriented model of conceptual competence based on an interdisciplinary approach. The author points out that the integration of ecological and

psychological knowledge contributes to the formation of professional skills necessary for solving modern problems in various fields. Zameliuk (2020) in his study considers the ecological trail as an effective tool for the formation of ecological competence in preschool children. The author argues that practical activities and work in the natural environment allow students to develop a value-based attitude towards nature. Jørgensen (2008) emphasizes the diversity of models for developing environmental programs. He proposes a systematization of models that can be used for educational purposes to assess and predict environmental changes.

Klochko and Fedorets (2023) address the conceptualization of a cultural-artistic model of environmental competence for mathematics teachers. The authors note that integrating an environmental approach into educational disciplines can increase environmental awareness even among professionals working in traditionally non-environmental fields. Khuraskina (2017) examines the development of students' environmental and legal competence through environmental education. The author emphasizes the importance of combining educational and upbringing methods to form environmentally responsible behavior. Ridei and Tolochko (2018) explore issues of improving the environmental competence of teachers in the postgraduate education system. Their work demonstrates the importance of professional development for teachers in spreading environmental knowledge among students.

Dlimbetova et. al (2015) focus on the development of environmental competence in future specialists. They emphasize that environmental aspects should be integrated into professional training to promote the development of sustainable thinking and practical skills. McKay and colleagues (2022) consider the development of environmental models from the perspective of assessing their systemic quality. The authors highlight the role of qualitative modeling in educational programs aimed at developing environmental literacy. Özkan et al. (2024) propose the integration of environmental elements into STEM education through architectural design. Their research demonstrates new perspectives on environmental education based on a creative approach and interdisciplinarity.

The analysis of the presented studies confirms the need for a comprehensive approach to the formation of environmental competence. The integration of theoretical knowledge, practical skills, and reflective thinking, as well as the use of interdisciplinary and culturally adapted approaches, create the prerequisites for the successful development of environmental education. To achieve this goal, it is important to consider the relationship between theoretical training, practical tasks, and reflective activities.

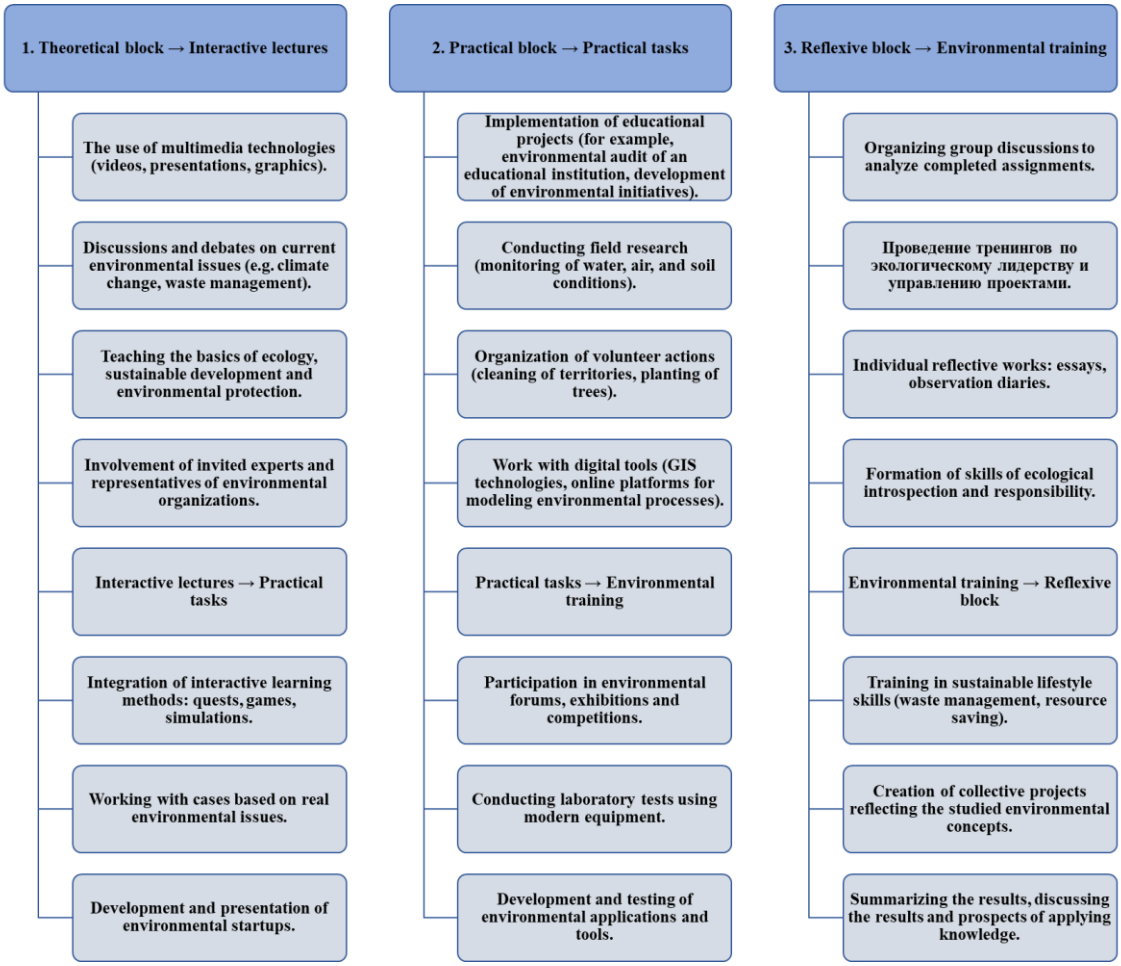
In response to these challenges, we have developed a model for building environmental competence aimed at creating a systematic approach to learning. This model combines theoretical study, practical activities, and reflective thinking, ensuring the comprehensive development of students. The main goal of the model is to develop the knowledge, skills, and values necessary for students to gain a deep understanding of environmental issues, make responsible decisions, and actively participate in solving them (Figure 1).

The goal of the integrative model for developing environmental competence is to create a holistic educational environment that ensures the systematic development of students' knowledge of ecology and sustainable development (cognitive component), practical skills for solving environmental problems (practical component), and value orientations aimed at environmentally responsible behavior (axiological component) (Figure 1).

The model aims to integrate theoretical, practical, and reflective components through interactive lectures, practical assignments, and environmental training. It promotes the active involvement of students in the learning process, develops their critical thinking and independent analysis skills, and encourages their willingness to participate in environmentally significant activities.

**Figure 1**

*Model for developing environmental competence: integrating theory, practice, and reflection*




This model is focused on training environmentally literate specialists who can respond effectively to modern challenges of sustainable development. It provides for close interaction between all stages of training, creating conditions for students to develop environmental thinking and skills that can be applied both in their professional and everyday lives. Each block of the model performs its own unique function and contributes to the comprehensive development of environmental awareness and skills in students.

Theoretical block - Interactive lectures. The first step in developing environmental competence is to provide students with basic knowledge about ecology and sustainable development. The use of interactive lectures accompanied by multimedia presentations, video materials, and graphs contributes to the creation of an engaging educational environment and better assimilation of the material. To enhance understanding of complex environmental issues, discussions and debates are organized in which students discuss contemporary challenges and propose possible solutions. This is consistent with the approach proposed by Pedersen and Bang (2015), who emphasizes the importance of a subjective environmental position and dialectical analysis. The involvement of experts from environmental organizations enhances the practical focus of the training, which is in line with Vdovenko (2022) recommendations on the need to integrate external resources into the educational process. The conceptual basis of the block also echoes the work of Stagl (2017), which emphasizes the role of an interdisciplinary and integrative approach in the formation of environmental literacy.

Practical block - Practical tasks. Practice-oriented training is aimed at consolidating theoretical knowledge by completing tasks that are close to real-life conditions. Students conduct environmental audits of the territory, develop greening projects, and monitor water, air, and soil. These forms of activity shape project thinking and decision-making skills, as emphasized in the works of Özkan et al. (2024) on the importance of project and STEM activities for the formation of competencies. The use of digital technologies such as GIS and environmental process modeling plays an important role, as confirmed by the research of Jørgensen (2008) and McKay et al. (2022), which emphasizes the importance of model quality assessment and systematic analysis of environmental data.

Reflective block - Ecological training. Reflective activity plays a key role in helping students understand the significance of their actions and develop a personal position. The block includes environmental training, group discussions, and leadership sessions. Individual assignments (essays, observation diaries) contribute to the formation of a critical attitude towards environmental issues and personal responsibility, which is in line with the approach of Cotska and Kuzmenko (2019), who emphasize the role of artistic and value analysis and reflection in teacher training. The effectiveness of such methods is also confirmed by Vdovenko (2022), study, which emphasizes the need to develop internal motivational attitudes in students through reflection on personal contribution.

Practical tasks - Ecological training. Student activity outside the classroom expands the scope of formal education. Participation in environmental forums, competitions, the development of digital applications, and laboratory research allow students to apply their knowledge in practice and contribute to the creation of innovative solutions that reflect contemporary challenges, as proposed by Özkan et al. (2024) in the context of STEM education and architectural solutions.

Ecological training - Reflective block. The educational process culminates in collective projects that reflect the environmental concepts and sustainable behavior skills that have been learned. Practices such as waste sorting, energy conservation, and responsible lifestyles are integrated into students' daily practices. Final discussions allow for an assessment of the effectiveness of the material's assimilation and the prospects for its application, which is in line with the ideas of McKay et al. (2022) on the need to evaluate the quality of systemic changes and behavior models.

Interconnection of blocks. The model assumes a logical continuity between blocks: theoretical knowledge gained in lectures is applied in practical tasks, the results of which are interpreted within the framework of environmental training. The cycle is completed by reflection, allowing students to assess their environmental activity and formulate new goals. This approach corresponds to the systemic model of environmental education focused on sustainable development, as emphasized in the works of McKay et al. (2022) and Jørgensen (2008).

The model for developing environmental competence presented in this paper demonstrates a systematic approach to learning that combines theory, practice, and reflection. This organization of the learning process helps students develop not only in-depth knowledge but also the practical skills needed to solve contemporary environmental problems.As a result of implementing this model, students achieve the following learning outcomes, as shown in Table 1.

**Table 1**

*Expected learning outcomes according to the model*

| | **Learning component** | | |
|---|---|---|---|
| | ***Cognitive component*** | ***Practical component*** | ***Axiological component*** |
| **Learning outcomes** | Mastering the basic concepts and principles of ecology, sustainable development and environmental protection. | Knowledge of methods of environmental monitoring, field research and laboratory work. | Formation of a valued attitude towards nature and an understanding of personal responsibility for its preservation. |
| | Ability to analyze modern environmental problems (climate change, waste management, etc.). | Experience in implementing educational projects, participating in volunteer actions, forums, competitions, and startup development. | Development of sustainable lifestyle skills (resource conservation, waste minimization). |
| | The ability to apply theoretical knowledge to solving applied problems. | Digital technology skills (GIS, modeling, environmental applications). | The ability for environmental introspection and collective project activity. |

Thus, the model we have developed ensures the formation of environmentally literate, motivated and socially responsible specialists who are ready for professional activity and active participation in solving the problems of sustainable development.

During the testing of the model for developing environmental competence, significant improvements were observed in the cognitive, axiological, and practical components among students in the experimental group compared to the control group.

Table 2 demonstrates changes in the levels of cognitive, axiological, and practical components of environmental competence among students in the experimental and control groups in the areas of “Biology-Natural Science” and “Pedagogical Biology.” The data on the initial and final levels of competence are presented, allowing us to assess the impact of the proposed model for the formation of ecological competence. The experimental groups showed a more significant increase in all components, which confirms the effectiveness of the model, especially in the development of axiological and practical skills (Table 2).

**Table 2**

*Changes in the levels of environmental competence of students in the experimental and control groups*

| **Groups / Components** | **Cognitive (%)** | **Axiological (%)** | **Practical (%)** |
|---|---|---|---|
| Entry level Experimental (Biology-Natural Sciences) | 45 | 35 | 57 |
| Final level Experimental (Biology-Natural Sciences) | 65 | 65 | 85 |
| Entry level Experimental (Pedagogical Biology) | 48 | 45 | 65 |
| Final level Experimental (Pedagogical Biology) | 61 | 74 | 84 |
| Entry level Control (Biology-Natural Sciences) | 36 | 51 | 49 |
| Final level Control (Biology-Natural Sciences) | 58 | 79 | 67 |
| Entry level Control (Pedagogical Biology) | 42 | 36 | 57 |
| Final level Control (Pedagogical Biology) | 69 | 78 | 84 |

This Table 2 demonstrates changes in the levels of cognitive, axiological and practical components of environmental competence among students of experimental and control groups. In the experimental group in the Biology-Science direction, the level of the cognitive component increased from 45% to 65%, indicating a significant increase in knowledge and effectiveness of the proposed model. The axiological component increased from 35% to 65%, indicating the formation of environmental values and the successful use of reflective methods. The practical component showed an increase from 57% to 85%, which confirms the development of practical skills and high performance of tasks. In the experimental group in the direction of “Pedagogical Biology”, the cognitive component increased from 48% to 61%, which reflects an increase of 13% and indicates a good assimilation of theoretical material. The axiological component increased from 45% to 74%, which demonstrates a significant increase in awareness and environmental responsibility.

The control group in the direction "Biology-natural science" also showed positive dynamics, but the results are inferior to the experimental group. The cognitive component increased from 36% to 58%, reflecting the influence of the standard educational program, although the increase was lower. The axiological component increased from 51% to 79%, demonstrating some effectiveness of traditional approaches to the formation of values. The practical component showed an increase from 49% to 67%, indicating a positive effect, but it was also lower than in the experimental group. In the control group in the direction of "Pedagogical Biology" the cognitive component increased from 42% to 69%, the increase amounted to 27%, which even surpassed the indicators of the experimental group. The axiological component increased from 36% to 78%, which demonstrates a high level of value formation, probably due to the features of the standard program. The practical component increased from 57% to 84%, which is a significant improvement and comparable to the experimental group.

To statistically evaluate the obtained data, correlation analysis and calculation of Student's t-criterion were carried out to identify the relationships between the components of environmental competence, as well as the differences in effectiveness between the experimental and control groups.

The correlations between cognitive, axiological and practical components of environmental competence were calculated using Pearson's correlation coefficient according to the formula:

$$r = \frac{\sum(x_i - \overline{x})(y_i - \overline{y})}{\sqrt{\sum(x_i - \overline{x})^2 \cdot \sum(y_i - \overline{y})^2}}$$

The results showed:

- A strong positive correlation between cognitive and axiological components ($r = 0.81$; $p = 0.014$),
- a very strong positive correlation between cognitive and practical components ($r = 0.96$; $p = 0.0002$),
- moderate but significant correlation between axiological and practical components ($r = 0.73$; $p = 0.039$).

These data confirm that the development of one of the components of environmental competence is accompanied by the growth of the rest, which proves the need for an integrated approach to training.

To identify the statistical significance of differences between the experimental and control groups, Student’s T-criterion for independent samples was used according to the formula:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

$\bar{x}_1$, $\bar{x}_2$ — are mean values of increment,
$s_1^2$, $s_2^2$ —are variance,
$n_1$, $n_2$ — are sample sizes.

The results showed:

- for the direction “Biology-Science”: t = 0.79; p = 0.47 - differences between groups are statistically insignificant,

- for the direction “Pedagogical Biology”: t = -1,71; p = 0,16 - also the absence of statistically significant differences, despite the presence of positive dynamics.

Despite the absence of a significant difference according to the t-criterion (which may be due to the small sample), the experimental group showed higher gains in all components, especially in the axiological and practical aspects. This is confirmed by the high correlation between the components and indicates the effectiveness of the proposed model of environmental competence formation.

In general, the experimental group showed more significant improvements in all components, especially in the formation of axiological and practical skills, which confirms the effectiveness of the proposed model. The control groups also showed positive dynamics, which indicates a certain effectiveness of standard educational programs. However, the increment in the experimental groups was higher, which emphasizes the advantages of the proposed model. The differences between the directions manifested themselves in the fact that students of pedagogical biology showed a greater increase in the cognitive component, while students of biology-natural science had a more noticeable improvement in practical skills. Thus, the proposed model contributes to a more effective formation of environmental competence, especially in the aspects of values and practical skills, compared to standard educational programs.

**Figure 2**

*Dynamics of changes in the levels of cognitive, axiological and practical components of environmental competence of students of experimental and control groups.*

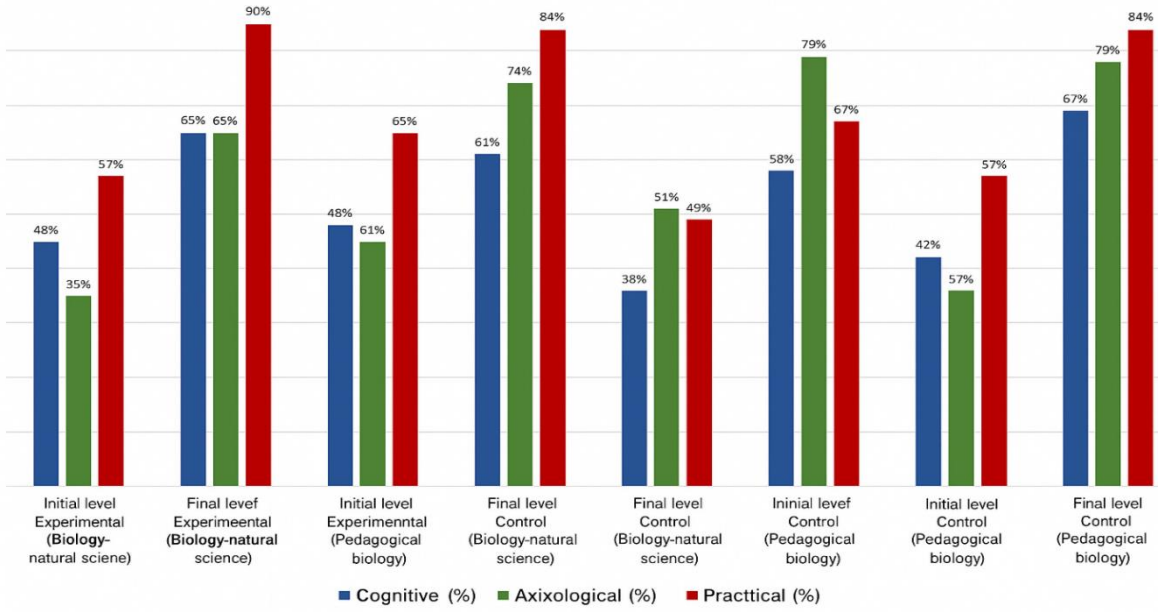


Figure 2 demonstrates the dynamics of changes in the levels of environmental competence for each component for both groups. The significant increase of indicators in the experimental group confirms the effectiveness of the proposed model, which combines theoretical study, practical activity and reflexive reflection. This indicates the high potential of the model for further implementation in the educational process to form sustainable knowledge, values and skills necessary for solving environmental problems. The proposed model thus contributes to a more effective formation of environmental competence, especially in the aspects of values and practical skills, compared to standard educational programs.

**Conclusion.**

The study confirmed the high significance of the systemic, integrative approach to the formation of environmental competence in the system of higher education. The developed model, including interrelated theoretical, practical and reflexive blocks, demonstrated its effectiveness in the formation of students' key components of environmental competence: knowledge, values and practical skills necessary for solving actual environmental problems.

The results of approbation showed that students of the experimental groups achieved significantly higher indicators of cognitive, axiological and especially practical components compared to the control groups. This was possible due to the introduction of practice-oriented tasks, the use of digital technologies (including GIS-platforms), participation in environmental projects, as well as the use of reflection methods that promote the awareness of personal responsibility and the formation of sustainable value orientations.

The control groups trained under traditional programs also demonstrated positive dynamics, but their rates of environmental competence development were lower. This allows us to conclude that the proposed model is more effective than standard educational approaches.

The main advantages of the developed model are as follows:

- Integration of cognitive, axiological and practical components, providing holistic development of environmental competence.
- Increased motivation and involvement of students through participation in real environmental projects and the use of modern digital tools.
- Formation of sustainable values and environmentally responsible behavior necessary for professional activity in the conditions of sustainable development.

The proposed model has a high degree of adaptability and can be implemented in educational programs of different orientation - biological, ecological, pedagogical and interdisciplinary. The results of the study emphasize the need for its further improvement, including the integration of new digital platforms, flexible learning formats and interdisciplinary interaction.

Thus, the developed model is a significant step towards the modernization of environmental education, contributing to the training of competent, ecologically literate and socially responsible professionals who are able to effectively respond to the challenges of the modern world and contribute to the sustainable development of society.

**Conflict of Interest Statement**

The authors declare no potential conflicts of interest regarding the research, authorship, or publication of this article.

**Author Contributions**

Nazerke Maratkyzy: Conceptualization, Supervision, Writing – Review & Editing, Project administration; Anargul Sharipkhanova: Methodology, Formal analysis, Investigation,

Writing – Original Draft; Sholpan Abilova: Validation, Data Curation, Writing – Original Draft; Aiman Karabalayeva: Visualization, Writing – Original Draft, Formal analysis.

**References**

Abdallah, L., & Forawi, S. (2017). Investigating leadership styles and their impact on the success of educational institutions. *The International Journal of Educational Organization and Leadership, 24*, 19–30. https://doi.org/10.18848/2329-1656/CGP/v24i02/19-30

Dlimbetova, G., Aliyeva, A., & Ayazbayeva, A. (2015). Development of ecological competence for future professions. *Biosciences Biotechnology Research Asia, 12*(1), 311–319. https://doi.org/10.13005/bbra/1667

FSFEI of HE "I.N. Ulyanov Chuvash State University", & Khuraskina, N. V. (2017a). Students' ecological and legal competence development based on ecological upbringing and education (pp. 121–123). https://doi.org/10.21661/r-117190

Jørgensen, S. E. (2008). Overview of the model types available for development of ecological models. *Ecological Modelling, 215*(1–3), 3–9. https://doi.org/10.1016/j.ecolmodel.2008.02.041

Karter, J. M. (2019). An ecological model for conceptual competence in psychiatric diagnosis. *Journal of Humanistic Psychology.* https://doi.org/10.1177/0022167819852488

Klochko, O., & Fedorets, V. (2023). Conceptualization of the cultural and artistic model of the ecological competence of the mathematics teacher. *Educological Discourse, 41*(2). https://doi.org/10.28925/2312-5829.2023.212

Liulenko, S., & Podzerei, R. (2022). Formation of ecological competence of the individual as one of the main tasks of sustainable development education. *Ecological Sciences, 42*(3), 226–229. https://doi.org/10.32846/2306-9716/2022.eco.3-42.38

Lutsk Pedagogical College, & Zameliuk, M. (2020). Ecological trail as a component of the development of ecological competence of preschool children. *Education and Development of Gifted Personality, 3*, 38–42. https://doi.org/10.32405/2309-3935-2020-3(78)-38-42

McKay, S., Richards, N., & Swannack, T. (2022). *Ecological model development: Evaluation of system quality*. Engineer Research and Development Center (U.S.). https://doi.org/10.21079/11681/45380

Ogbu, J. U. (1981). Origins of human competence: A cultural-ecological perspective. *Child Development, 52*(2), 413. https://doi.org/10.2307/1129158

Özkan, C., Çepni, S., Maratkyzy, N., Vural Arslan, T., & Durak, S. (2024). A new perspective on STEM education: The possible contributions of architectural education. *Journal of Turkish Science Education, 21*(3), 599–619. https://doi.org/10.36681/tused.2024.032

Palshkova, I. O. (2003). Methodological principles of professional formation of pedagogical activity of future teachers. *Educational Dimension, 6*, 82–83. https://doi.org/10.31812/educdim.5222

Pedersen, S., & Bang, J. (2016). Youth development as subjectified subjectivity – A dialectical-ecological model of analysis. *Integrative Psychological and Behavioral Science, 50*(3), 470–491. https://doi.org/10.1007/s12124-015-9337-z

Ponomarova, N., & H. S. Skovoroda Kharkiv National Pedagogical University. (2018). Theoretical and methodological bases for future IT teachers training for professionally-oriented work with pupils. *Continuing Professional Education: Theory and Practice*, (1–2), 47–51. https://doi.org/10.28925/1609-8595.2018(1-2)4751

Ridei, N., & Tolochko, S. (2018). Development of teacher ecological competence in the system of postgraduate pedagogical education for sustainable development. *Humanities Science Current Issues, 2*(21), 144–148. https://doi.org/10.24919/2308-4863.2/21.167324

Sotska, H., & Kuzmenko, H. (2019). Methodological aspects for the preparation of future teachers of fine arts. *ScienceRise: Pedagogical Education, (2)29*, 17–21. https://doi.org/10.15587/2519-4984.2019.161529

Stagl, S. (2017). Ecological economics as a new integrative approach. In *The WTO, agriculture and sustainable development* (pp. 311–316). https://doi.org/10.4324/9781351282123-18

Vdovenko, T., & Izmail State University of Humanities. (2022). Formation of ecological competence among university students. *Scientific Bulletin of the Izmail State University of Humanities. Section "Pedagogical Sciences", (60)*, 9–14. https://doi.org/10.31909/26168812.2022-(60)-1

## Information about authors

***Nazerke Maratkyzy*** — 3rd-year doctoral student of the educational program 8D01505 Biology, Department of Biology, East Kazakhstan State University named after Sarsen Amanzholov, Ust-Kamenogorsk, Kazakhstan, ORCID: 0009-0005-0713-2182, e-mail: nazerke.myktybaeva@mail.ru

***Anargul Sharipkhanova —*** Candidate of Biological Sciences, Associate Professor, Department of Biology, East Kazakhstan State University named after Sarsen Amanzholov, Ust-Kamenogorsk, Kazakhstan, ORCID: 0000-0001-8533-0321, e-mail: anargul-sharipha@mail.ru

***Sholpan Abilova—*** Phd, High school of nature sciens, Astana International University, Astana, Kazakhstan e-mail: sholpanajana@gmail.com, ORCID: 0000-0001-8372-1812 . ***(corresponding author)***

***Aiman Karabalayeva—*** Phd, High school of nature sciens, Astana International University, Astana, Kazakhstan e-mail: karabalayevaa@gmail.com, ORCID: 0000-0001-6539-2541