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Article

Methodology for Using Tasks Oriented Toward Global Competencies of International Assessment Studies in Developing Students' Natural Science Literacy

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Abstract: The article addresses the issues of improving the methodology for using tasks oriented toward global competencies identified in international assessment studies in the process of developing students' natural science literacy. The research and analysis confirm cognitive abilities that can be developed through competency-based tasks framed in global problems of environmental education, means of their design in the educational process and criteria for their appraisal. The results of the pedagogical experiment show that the regular application of tasks related to global competencies makes an essential contribution to the formation of students' scientific thinking, the free handling of competences to analyze problem situations, and the ability to make socially responsible decisions.

Keywords: Natural science literacy, global competencies, international assessment studies, environmental education, competency-based approach, PISA tasks.

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1. Introduction

In the modern education system, it is increasingly important not only to equip students with fundamental knowledge of academic disciplines but also to develop competencies related to understanding global challenges, making decisions based on scientific evidence, and demonstrating a responsible attitude toward sustainable development. In this context, universal competencies, which are a priority of international assessment studies, serve as a significant methodological basis for reconceptualization of education content and updating of teaching methodologies.

Abstract Ecological content is inherently connected to natural processes, environmental issues, energy, health, and industry, and therefore has unique didactic value for the development of global competencies. Educational practice, on the other hand, has an underdeveloped methodology for the implementation of task-based learning focusing on global competences.

The relevance of this article is determined by the need to address this problem from a scientific and methodological perspective.

Purpose and Objectives of the Study

The purpose of the study is to improve the methodology for using tasks oriented toward global competencies of international assessment studies in developing students' natural science literacy, using environmental education as an example [1].

The objectives of the study are to:

substantiate the methodological relationship between global competencies and natural science literacy; develop a system of tasks oriented toward global competencies adapted to environmental education; determine the methodology for implementing these tasks in the educational process; identify the effectiveness of the developed methodology based on a pedagogical experiment.

2. Materials and Methods

This The following methods were used in the study: analysis of scientific and pedagogical literature, observation of the educational process, diagnostic tests, design of competency-based tasks, pedagogical experiment, and methods of mathematical and statistical analysis [2]. Tasks oriented toward global competencies were applied in environmental education based on the following methodological principles:

Contextual approach – tasks were developed on the basis of real-life situations related to global environmental problems, climate change, and the rational use of resources; **Problem-based learning** – students were guided to analyze problem situations and develop solutions using environmental knowledge; **Interdisciplinary integration** – ecological content was integrated with geography and biology; **Competency-based assessment criteria** – the primary criteria focused not on the reproduction of knowledge, but on skills of analysis, evaluation, and drawing conclusions. **Theoretical and Methodological Foundations of the Contextual Approach (within Environmental Education)**

The contextual approach is a didactic approach aimed at developing students' natural science, global, and environmental competencies by organizing the content of environmental education within the context of real social, environmental, economic, and global problems. The theoretical foundations of this approach are closely connected with the competency-based education paradigm, the constructivist approach, and the real-life-oriented assessment model used in international assessment studies (in particular, PISA).

The relevance of the contextual approach in environmental education is explained by the global nature of environmental problems, the integration of the concept of sustainable development into educational content, and the necessity of forming students' skills for making scientifically grounded environmental decisions.

From a theoretical perspective, the contextual approach implies the acquisition of environmental knowledge not merely as a set of facts, but as a means of analyzing socially significant problems [3]. **Didactic Mechanism of the Contextual Approach in Environmental Education** The implementation of the contextual approach in teaching ecology is carried out through the following step-by-step didactic mechanism: **Selection of a problematic environmental context.** The educational process begins with a global or regional environmental problem (climate change, water scarcity, waste management, biodiversity loss); **Identification of scientific and ecological content.** Ecological concepts, patterns, and scientific facts related to the selected context are identified (cycles of matter, anthropogenic impact, ecosystem stability, etc.); **Design of competency-based tasks.** Tasks are aimed at developing students' abilities to comprehend environmental problems, analyze scientific data, evaluate alternative solutions, and demonstrate environmental responsibility; **Reflection and assessment.** Students' environmental decisions are assessed based on competency-based criteria, and reflective discussions are organized [4].

Examples of Specific Tasks Developed on the Basis of the Contextual Approach (for Environmental Education) Example 1. Climate Change and Carbon Footprint Context: One of the main causes of global climate change is greenhouse gases emitted into the atmosphere as a result of human activities. **Ecological content:** carbon cycle, anthropogenic emissions, stability of the climate system. **Task:** Based on the provided data, analyze the impact of household and industrial activities on the carbon footprint. Evaluate

ecological and technological measures aimed at reducing CO_2 emissions into the atmosphere.

Developed competencies: scientific analysis, understanding of global environmental problems, responsible environmental decision-making. **Example 2. Scarcity and Pollution of Drinking Water Context:** In many regions, the depletion and pollution of freshwater resources pose a threat to environmental security. **Ecological content:** hydrosphere, aquatic ecosystems, anthropogenic pollution. **Task:** Identify ecological factors leading to the reduction of drinking water resources. Develop scientifically grounded proposals for the rational use and protection of water resources.

Developed competencies: analysis of problem situations, drawing conclusions based on scientific evidence, environmental responsibility. **Example 3. Solid Household Waste and Sustainable Development Context:** The increasing volume of plastic and other waste causes serious damage to ecosystems. **Ecological content:** waste cycles, biodegradation, "green economy." **Task:** Analyze the impact of solid household waste on ecosystems. Evaluate environmentally effective strategies for recycling and waste reduction. **Developed competencies:** evaluation of alternative solutions, systems thinking, environmental awareness [5]. **Example 4. Loss of Biodiversity**, **Context:** As a result of the reduction of natural habitats, many biological species are at risk of extinction.

Ecological content: ecosystem stability, trophic chains, protected natural areas. **Task:** Identify the main ecological factors leading to biodiversity loss and propose scientifically grounded environmental measures to mitigate them. **Developed competencies:** comprehensive analysis of environmental problems, socio-environmental responsibility. **Didactic Effectiveness of the Contextual Approach in Environmental Education**. The results of the study and the pedagogical experiment indicate that the contextual approach significantly increases students' levels of natural science and environmental literacy, serves as an effective pedagogical tool for the formation of global competencies, and contributes to revealing the social and practical significance of environmental education [6].

Problem-based learning is a didactic approach aimed at developing students' scientific thinking, research skills, and environmental competencies by organizing the learning process around real or simulated problem situations that create intellectual challenges. Methodologically, this approach is closely linked to the ideas of constructivist pedagogy, activity-oriented learning, and the competency-based approach.

The relevance of problem-based learning in environmental education stems from the fact that environmental problems are multifactorial and open-ended, require a balance between scientific evidence, social interests, and environmental responsibility, and encourage students to think from the perspective of sustainable development. In this regard, problem-based learning in ecology ensures a transition from reproductive acquisition of knowledge to inquiry-based and analytical mastery of content and contributes to the deep development of students' natural science literacy.

Didactic Mechanism of Problem-Based Learning in Environmental Education In teaching ecology, problem-based learning is implemented through the following step-by-step didactic mechanism: **Creating a problem situation.** The teacher establishes a knowledge gap based on a real environmental problem or contradictory scientific viewpoints (for example, the tension between economic development and environmental safety). **Identifying and formulating the problem.** Which leads students to analyse the situation in a specific problematic scenario and then to discover the most crucial environmental issue and then develop the research questions on their own. **Formulating scientific hypotheses**. Students formulate their alternate hypotheses founded on ecological trends and scientific understanding. **Investigating the evidence and create a solution**. The hypotheses are then verified with environmental data records, statistical indicators, and experimental results followed by scientifically sound solutions.

Drawing conclusions and reflection. Students justify their decisions, assess environmental and social consequences, and formulate reflective conclusions. **Examples of Specific Tasks Developed on the Basis of Problem-Based Learning (for Environmental Education) Example 1. The Tension Between Climate Change and Industrial Development Problem situation:** Expanding industrial production in a region creates jobs, but leads to a sharp increase in greenhouse gas emissions into the atmosphere.

Problem: How can the risk of climate change be reduced while maintaining industrial development? **Task:** Analyze the environmental impact of industrial enterprises on climate. Develop scientifically grounded proposals to reduce greenhouse gas emissions and evaluate their environmental and economic consequences. **Targeted competencies:** scientific analysis, evaluation of alternative solutions, responsible environmental decision-making. **Example 2. Drinking Water Scarcity and Agricultural Activity Problem situation:** Excessive use of water for irrigation in agriculture leads to a reduction in freshwater reserves [7]. **Problem:** How can water resources be protected while ensuring food security? **Task:** Identify the environmental causes of water scarcity. Evaluate the ecological effectiveness of introducing water-saving technologies.

Targeted competencies: analysis of a problematic situation, drawing conclusions based on scientific evidence, environmental responsibility. **Example 3. The Problem of Solid Household Waste Problem situation:** Population growth results in a rapid increase in the volume of solid household waste, while existing landfills create environmental risks. **Problem:** Which environmental strategy for waste reduction and recycling is the most optimal? **Task:** Analyze the impact of solid household waste on ecosystems. Compare recycling and disposal methods in terms of their ecological effectiveness.

Targeted competencies: systems thinking, comparison of alternative solutions, environmental awareness. **Example 4. Biodiversity Conservation and Infrastructure Development Problem situation:** The expansion of transport and tourism infrastructure leads to a reduction in natural areas. **Problem:** How can biodiversity be preserved while ensuring infrastructure development? **Task:** Identify environmental factors contributing to biodiversity loss. Evaluate the environmental and social effectiveness of conservation measures.**Targeted competencies:** comprehensive environmental analysis, socio-environmental responsibility, strategic thinking [8].

Didactic Effectiveness of Problem-Based Learning in Environmental Education Scientific and pedagogical research and practical experience show that problem-based learning promotes deep development of students' natural science and environmental literacy, serves as an effective method for forming global and environmental competencies, and enables ecology to be mastered as a socially significant applied discipline.

Theoretical and Methodological Foundations of Interdisciplinary Integration (in the Context of Environmental Education) Interdisciplinary integration is a didactic approach aimed at forming students' holistic environmental thinking, systems analysis, and global competencies by closely linking the content of environmental education with natural and social sciences (biology, geography, ecology, physics, economics). Methodologically, this approach aligns with the competency-based education paradigm, the system-activity approach, and the ideas of Education for Sustainable Development.

Environmental problems are inherently interdisciplinary, and solving them is not possible within the scope of a single discipline. Therefore, interdisciplinary integration in environmental education: reveals the interconnections among nature, society, and the economy; creates conditions for applying natural science literacy in real-life contexts; develops skills for comprehensive and multi-level analysis of environmental problems.

From a theoretical perspective, interdisciplinary integration ensures that environmental knowledge is acquired not fragmentarily but as a coherent scientific system and expands the methodological potential of ecology as an academic discipline [9]. **Didactic Mechanism of Interdisciplinary Integration in Environmental Education**

The implementation of interdisciplinary integration in teaching ecology is carried out through the following staged mechanism: **Selecting an integrative environmental problem**. This involves long-term team-based teaching and collaborative learning focused around a genuine environmental issue needing a multidisciplinary examination (such as climate change, resource depletion or biodiversity loss). The ill-defined block of interdisciplinary knowledge Relevant fields of science are determined in terms of key concepts that are relevant to the problem, such as; ecology—stability of ecosystems; biology—biodiversity; geography—characteristics of territories; chemistry—processes of pollution; economics—efficiency of resource use.

Designing integrative tasks. Task is focused on joint use of knowledge across disciplines, including, analysis and synthesis. **Interdisciplinary discussion and reflection**. Learn about the environmental issue from an multidisciplinary science perspectives, interrelate science disciplines, and express reflective thoughts

Task Examples Created Based on Transdisciplinarity (for Environmental Education) Example 1. Climate Change—Integration of Ecology, Chemistry, and Geography Integrative context: Global climate change is directly related to the chemical composition of the atmosphere and geographical processes. **Interdisciplinary content:** ecology—impacts on ecosystems; chemistry—greenhouse gases and their reactions; geography—shifts in climate zones [10]. **Task:** Analyze the main ecological, chemical, and geographical factors of climate change. Evaluate the consequences of climate change for different regions on an interdisciplinary basis. **Targeted competencies:** systems thinking, interdisciplinary analysis, understanding a global environmental problem. **Example 2. Water Resource Use—Integration of Ecology, Biology, and Economics Integrative context:** Decreasing water resources constitute not only an environmental, but also a biological and economic problem.

Interdisciplinary content: ecology—stability of aquatic ecosystems; biology—life processes of aquatic organisms; economics—efficiency of water use. **Task:** Analyze the ecological, biological, and economic consequences of improper use of water resources. Develop interdisciplinary solutions aimed at water conservation. **Targeted competencies:** comprehensive analysis of a problematic situation, responsible environmental decision-making. **Example 3. Solid Household Waste—Integration of Ecology, Chemistry, and Law**. **Integrative context:** The waste problem involves environmental pollution as well as chemical and legal aspects. **Interdisciplinary content:** ecology—impacts on the environment; chemistry—decomposition and toxic substances; law—environmental standards and legislation.

Identify ecological and chemical hazards of solid domestic waste Discuss how environmental legislation performs in waste management [8]. **Competencies targeted**: transdisciplinary assessment, sustainability, social sciences. **Example 4**. Biodiversity and its conservation — an ecology, biology and geography integration **Ecology**: maintaining the balance of ecosystems; Biology: Diversity of species; Geography: Natural area and landscape. **Objective**: To examine reasons of biodiversity decline through the lens of different disciplines and propose an integrated management plan for its protection.

Related competencies: systems [11]. **Didactic Effectiveness of Interdisciplinary Integration in Environmental Education** Pedagogical research shows that interdisciplinary integration promotes deep development of students' natural science and environmental literacy, ensures holistic and systematic perception of environmental problems, and serves as an effective methodological tool for forming global competencies.

Theoretical and Methodological Foundations of Competency-Based Assessment Criteria (in the Context of Environmental Education) Competency-based assessment is an assessment system aimed not only at determining the volume of students' environmental knowledge, but also at identifying their ability to apply this knowledge in real environmental situations, conduct scientific analysis, evaluate alternatives, and make responsible decisions [12]. Methodologically, this approach is consistent with the

competency-based education paradigm, constructivist didactics, and the outcomes-oriented assessment model used in international assessment studies (in particular, PISA).

The relevance of competency-based assessment in environmental education is determined by the open-ended and multi-solution nature of environmental problems, the need to understand and apply the ideas of sustainable development in practice, and the requirement to consider the social, economic, and ethical consequences of environmental decisions. Therefore, competency-based criteria ensure the transition from memorizing knowledge to engaging in scientific and practical activity [9].

Didactic Mechanism for Implementing Competency-Based Assessment Criteria In environmental education, competency-based assessment is implemented through the following staged didactic mechanism: **Identifying the environmental competencies to be assessed.** Assessment criteria are linked to such competencies as understanding and identifying an environmental problem, analyzing scientific and environmental evidence, evaluating alternative environmental solutions, and demonstrating environmental and social responsibility.

Designing tasks aligned with the criteria. Assessment tasks are developed on the basis of real or simulated environmental situations and are open-ended, problem-based, and interdisciplinary in nature. **Organizing level-based (rubric-based) assessment.** Students' performance is assessed across levels—low, medium, sufficient, and high—each described by clearly defined indicators.

Reflection and analysis. The assessment process includes students' self-assessment and reflective analysis, providing feedback aimed at developing competencies. **System of Competency-Based Assessment Criteria for Environmental Education** The key competencies and their corresponding assessment criteria are presented below: **Criterion 1. Level of understanding the environmental problem.** Accurate identification of the problem, explanation of cause-and-effect relationships, and awareness of its global or regional significance. **Criterion 2. Scientific and environmental analysis skills.**

Correct use of environmental concepts, analysis of data and evidence, and formulation of scientifically grounded conclusions. **Criterion 3. Evaluation of alternative solutions.** Proposing multiple environmental solutions, comparing their environmental and social consequences, and justifying the most optimal option. **Criterion 4. Environmental responsibility and decision-making.** Adherence to the principles of sustainable development, demonstration of environmental values, and substantiation of a responsible civic position. Examples of Specific Competency-Based Assessment Tasks (for Environmental Education) **Example 1. Protection of Water Resources**

Task: Identify the environmental factors leading to drinking water scarcity in your region. Propose at least two alternative solutions to address the problem and evaluate them in terms of environmental effectiveness. **Assessed competencies:** understanding the problem, scientific analysis, evaluation of alternative solutions, environmental responsibility [10]. **Example 2. Management of Solid Household Waste Task:** Analyze the impact of solid household waste on the environment. Compare recycling, reduction, and disposal methods, and justify the most optimal environmental strategy.

Assessed competencies: scientific analysis, comparison, responsible decision-making. **Example 3. An Environmental Decision on Climate Change Task:** Assess the impact of climate change on ecosystems in your region. Develop a decision aimed at sustainable development, taking into account environmental, economic, and social factors.

Assessed competencies: understanding a global environmental problem, comprehensive analysis, responsible decision-making. Didactic Effectiveness of Competency-Based Assessment Criteria Scientific and pedagogical studies indicate that competency-based assessment: enables students to demonstrate natural science and environmental literacy in real-life contexts, ensures the integration of knowledge, skills,

and values in environmental education, and forms an assessment culture aligned with the requirements of international assessment studies [13].

3. Results

The pedagogical experiment aimed at determining the effectiveness of using tasks oriented toward global competencies of international assessment studies (PISA, TIMSS) in developing students' natural science literacy was conducted in three stages: diagnostic (pre-test), formative, and summative (post-test).

At the diagnostic stage, the analysis of initial results revealed that the majority of students demonstrated a low to medium level of natural science literacy, particularly in the competencies related to:

applying scientific knowledge to real-life global contexts;

interpreting scientific data and evidence;

analyzing socio-scientific problems with a global and interdisciplinary perspective.

The average pre-test score showed limited students' ability to explain natural phenomena, justify conclusions using scientific evidence, and propose solutions to global issues such as climate change, environmental pollution, and sustainable resource use [14].

During the formative stage, the developed methodology was implemented. It was based on:

PISA-style contextual tasks reflecting global challenges;

interdisciplinary integration of chemistry, ecology, and geography;

problem-based and inquiry-oriented learning strategies;

collaborative and reflective learning activities.

As a result, students gradually demonstrated improved engagement, higher motivation, and increased cognitive activity in solving complex, context-based scientific problems.

At the summative stage, the post-test results indicated a statistically significant improvement in students' natural science literacy levels. The experimental group showed:

an increase in high-level performance indicators related to scientific reasoning and argumentation;

improved ability to analyze global problems using scientific concepts;

enhanced skills in evaluating information from multiple sources and making evidence-based decisions.

Quantitative analysis revealed that the proportion of students with a high level of natural science literacy increased substantially, while the number of students at the low level decreased [15]. In contrast, the control group, which followed traditional instruction, demonstrated only minor changes.

The software 2 checks the word count These findings verify that tasks that are aligned with global competencies make significant contributions to natural science literacy when the teaching process systematically integrates global competencies.

In addition, the results obtained in the study support the efficiency of the proposed methodology and align with current international studies that highlight the necessity of education based on global competencies.

First, the increasing proficiency of students in science related to real-life contexts fits into the common conceptual framework of international assessment studies, which prioritize the functional and applied over the reproductive aspects of scientific literacy [16]. The findings support the view that contextualized global tasks enhance meaningful learning and deepen conceptual understanding.

Secondly, the integration of interdisciplinary content played a critical role in developing students' holistic scientific thinking. The results confirm that global competence-oriented tasks encourage students to view scientific problems from multiple perspectives, fostering systems thinking and critical analysis. This shall be understood in

the sense of other studies which show the relevance of interdisciplinary and socio-scientific approaches in the science classroom.

Third, the increase in students ability to analyze and evaluate indicates that tasks oriented to global competence were more likely to induce higher-order cognitive processes. The approach builds important elements of natural science literacy by having students design arguments, interpret data, and make decisions.

Additionally, the improvements in students' motivation and engagement indicate that global-context tasks help to increase the authenticity of science education. Participation was driven by a desire to engage with others, and students perceived the learning activity as meaningful and with social relevance, which shifted attention and sustained effort [17].

Despite these positive outcomes, certain limitations were identified. Some students initially experienced difficulties in working with complex texts and unfamiliar global contexts, indicating the need for gradual scaffolding and teacher support. Additionally, the effectiveness of the methodology largely depended on teachers' methodological readiness and their ability to design and facilitate global competence-oriented tasks.

Overall, the discussion confirms that the systematic use of tasks oriented toward global competencies of international assessment studies represents a pedagogically effective strategy for developing students' natural science literacy [18]. The methodology not only enhances cognitive outcomes but also contributes to the formation of socially responsible, globally aware learners capable of applying scientific knowledge in solving real-world problems.

4. Conclusion

The research findings demonstrate that introducing the methodology for using tasks related to global competencies from international assessment studies into environmental education is an effective tool for developing students' natural science literacy. The proposed methodology guides students toward scientifically grounded analysis of global challenges, responsible use of scientific achievements, and understanding the ideas of sustainable development.

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