

ECOLOGICAL IMPERATIVE AND CO-EVOLUTIONARY EDUCATION THROUGH METHODOLOGICAL SYNTHESIS

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Abstract

Modern higher education requires a strategic shift toward student-centered and competence-based approaches, as emphasized by the Bologna Process and recent EHEA communiqués. A critical challenge remains the formation of educational content that bridges the gap between fundamental theories and professional practice. This research, supported by the Institute for Human Sciences (IWM) under the Documenting Ukraine grant, proposes an integrated approach to modernize environmental education, specifically through the lens of regional water security. The study's objective was to create an effective didactic system that systematizes knowledge of natural-science theories while addressing urgent global and, crucially, regional water problems. For listeners, the issue of water security is particularly valuable when examined through a regional perspective, as it allows them to connect abstract global Sustainable Development Goals with the tangible ecological state of their own local basins and communities. The "Water Security" course serves as a primary example, integrating international water policy with regional environmental management into a cohesive module. The methodology employed included component analysis of ecological knowledge, educational experiments, and mathematical statistics to evaluate the completeness of knowledge acquisition. By focusing on regional cases—such as the pollution of local rivers or the depletion of water—students develop a co-evolutionary worldview and a deeper sense of professional responsibility. This localized approach ensures that the "ecological imperative" becomes a practical guide for future specialists rather than a theoretical concept. The essence of methodological synthesis in the content of education is to create a holistic didactic system that not only combines knowledge from different disciplines, but also ensures their interaction at the highest level - through the coordination of fundamental natural science theories, basic categories and principles. The study involved three years of experimental validation with over 600 listeners, demonstrating high didactic effectiveness. Results showed that students achieved an average knowledge acquisition coefficient of 0.85, significantly exceeding the satisfactory threshold. The integrated approach was implemented across three levels: internal disciplinary, interdisciplinary, and methodological synthesis. In conclusion, the integrated approach to "Water Security" not only improves the quality of professional training but also fosters environmental stewardship. By emphasizing the regional dimension of water problems, this model helps students master the complex international and local dimensions of environmental policy. Future research will focus on improving assessment methodologies for these integrated modules to ensure the continuity of educational objectives in a changing global climate.

Keywords: *Ecological imperative, co-evolutionary worldview, methodological synthesis, environmental responsibility, knowledge acquisition.*

1. Introduction

Improving the content of education as a strategic priority and a key direction of higher education reform the 2015 Yerevan, 2018 Paris, and 2020 Rome Communiqués identified improving educational content as a strategic priority for European higher education reform (Ministerial Conference Yerevan, 2015; Ministerial Conference Paris, 2018; Rome Ministerial Communiqué, 2020). In line with these EHEA recommendations, Ukrainian institutions must shift toward student-centered and competence-based approaches, emphasizing innovation, stakeholder dialogue, and empirical research (Rome Ministerial Communiqué, 2020).

Educational content is defined as a system of scientific knowledge, skills, and moral-aesthetic ideas mastered during learning (Munawaroh, 2017; Pawley, 2019). Its formation is a complex

methodological challenge influenced by technological progress, societal needs, and state policy (Cheung & Slavin, 2016; Kosmutzky & Nokkala, 2020; Little & Green, 2009).

Integration has emerged as a primary trend in overcoming the limitations of traditional disciplinary approaches. Today, this manifests in several forms:

- Interdisciplinary research at the boundaries of related fields.
- The application of general systems theory, cybernetics, and synergetics.
- Solving complex global issues, such as environmental crises, which require multi-disciplinary participation (Ampatzidis & Ergazaki, 2017; Ampatzidis & Ergazaki, 2018; Bezsonov et al., 2017; Menashy & Verger, 2019).

Ukraine's integration into the European Higher Education Area necessitates a change in educational philosophy. 21st-century culture demands professionals focused on innovation and human values (Mitryasova et al., 2020; Mitryasova & Pohrebennyk, 2020; Munawaroh, 2017). Natural science education, in particular, has the potential to address sustainable development through integrated courses and holistic knowledge structures (Mitryasova, 2020). To address these needs, research suggests a reorientation of curricula toward integrated issues (Mitryasova et al., 2017). As a practical example, we have developed an interdisciplinary training course to solve issues of understanding sustainable development.

The purpose of research is the creation of an effective didactic system through the integrated approach of a natural education, for example of water security course with a special emphasis on professional orientation.

The object is the natural education content of the students' preparation process, namely, students' training in the environmental specialty.

The subject of the research is the content of the interdisciplinary course on water safety for students of environmental specialties of universities.

2. Methods

To develop and evaluate the integrated training course, a multi-faceted methodology was employed, ranging from partial scientific approaches (such as component analysis of ecological knowledge and postoperative skill analysis) to general scientific methods like educational experiments and mathematical statistics. These methods facilitated the selection of curriculum material and the analysis of experimental data.

To measure students' proficiency, the study assessed the ratio of concepts correctly applied by students against the total possible definitions. While tasks primarily targeted the reproductive level of learning, the specific quantitative measure used to evaluate the depth of student understanding was the knowledge acquisition coefficient (Mitryasova, 2020).

3. Discussion

The modern paradigm of environmental education for Master's students is built upon a structured integrated approach, which functions as a specialized framework for designing educational content. This methodology transcends traditional disciplinary boundaries by coordinating and systematizing knowledge around core natural-science theories, basic categories, and a holistic scientific picture of the world. By implementing this approach, the curriculum effectively bridges the gap between theoretical knowledge and the practical necessity of making optimal management decisions.

The selection and structuring of educational material are guided by several foundational principles. These include the principle of systematicity, where the goals of natural science education are aligned with leading laws and theories, and the principle of fundamentalization, which ensures deep academic rigor. Furthermore, the content is heavily shaped by professional orientation, focusing on interdisciplinary connections that address urgent global challenges. Central to this framework is the disclosure of environmental crises, specifically climate change, sustainable development, and the deteriorating state of water resources (Bezsonov et al., 2017; Mitryasova & Pohrebennyk, 2020).

The practical application of the integrated approach occurs across three hierarchical levels. At the intradisciplinary and interdisciplinary levels, integration is achieved through the careful selection of facts, concepts, and methods tailored to specific specializations and humanistic values. At the highest level—methodological synthesis—the focus shifts to dialectical categories such as systems, structures, causality, and patterns. This synthesis allows students to perceive the relationship between elements and their consequences within a broader environmental context.

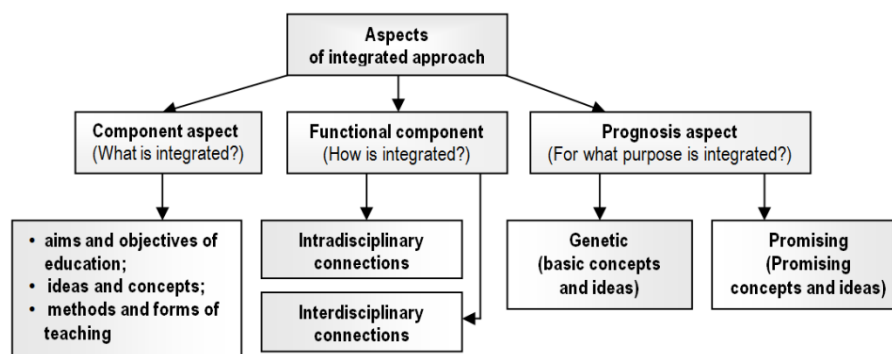
A primary example of this methodology is the Master's training course in Environmental Science, which prioritizes European practices in the field of water security. The course content is rooted in the

environmental imperative and the concept of co-evolutionary development between society and nature. By exploring topics such as integrated water management, environmental law, and pollution issues, the curriculum fosters a sense of responsibility for the quality of natural resources (Mitryasova & Pohrebennyk, 2017). Ultimately, this integrated model enhances students' awareness of European studies and equips them with the expertise to navigate the evolution of environmental management within the European Union.

The curriculum is built upon a robust interdisciplinary foundation, merging the core tenets of sustainable development strategies with extensive European experience in environmental water policy (Mitryasova, Koszelnik et al., 2020; Mitryasova & Pohrebennyk, 2020). By focusing on the integration of environmental requirements into diverse policy sectors, the course covers critical issues such as water monitoring, pollution control, purification technologies, and climate change. Furthermore, it incorporates an essential international dimension, examining the European Union's leading role in global environmental movements—including the Kyoto Protocol and the UNESCO Roadmap—and assessing the broader impact of European policy on global water security networks.

The practical execution of this integrated approach is governed by three primary analytical aspects: the component, functional, and prognosis dimensions. The component aspect addresses the fundamental question of *what* is being integrated, identifying the specific scientific elements and data points brought together. The functional aspect explores *how* integration occurs by facilitating the active operation of intra- and interdisciplinary connections. Finally, the prognosis aspect serves a dual purpose: the *genetic* area examines the origins of basic scientific concepts, while the *prospective* area identifies promising ideas and future trends in environmental management. This multi-layered framework ensures that students not only acquire current knowledge but also develop the capacity to anticipate and respond to evolving ecological challenges (Figure 1).

Figure 1. The most important aspects of integrated approach.



The course is interdisciplinary and connects the policy and tools of water monitoring and management, principally addressing EU and Ukraine practices of water quality, water resources, biodiversity, and, fisheries and their progressive integration.

Table 1. The main content of the course.

Topic	Main issues of the topic
The role of the EU in international environmental motions (e.g. Kyoto Protocol, UNESCO Roadmap for Implementing the Global Action Programme on Education for Sustainable Development, Sustainable Development Strategies).	History of the formation of the EU environmental foundation; the EU's place in international environmental law; EU institutions in the field of environmental protection; legal support for the concept of "sustainable development" in the EU.
The strategies of EU environmental policy.	General characteristics of EU environmental policy; the United Nations Environment Programme; UN climate conferences and the EU position; United Nations Environment Programme (UNEP), UN Climate Change Conferences: Bali, Poznan, Copenhagen, Cancún Transatlantic relations and climate change / EU & US relations on environmental issues.

Water and development in Europe: environmental sustainability as a precondition of European environmental policy and its best practices in water monitoring.	Water in numbers and facts; water Framework Directive as the main document for water monitoring; status of water resources; types of state water monitoring; a new order of water monitoring in Ukraine; comparative analysis of the monitoring format: as it was and how it will be; European experience in water monitoring.
Implementation of sustainable development programs to post-soviet countries.	Characteristics of sustainable development content from the UN's views; the role of ecological security in the sustainable development; environmental security of aquatic ecosystems: priority factor in development; assessment of environmental component in the region's development; effectiveness of the implementation of sustainable development programs in the post-soviet countries.
Water resources, water quality and climate change.	The water-resource potential of the hydrosphere; distribution of water resources; water resources of Ukraine; factors of formation of water composition; properties of natural waters; general requirements for drinking water quality in the world; requirements for water quality in Ukraine; drinking water and human health; adaptation to climate change.
Integrated water management: challenges for the 21 st century.	Water is the matrix of life; regional aspect of water supply: history question; characterization of water treatment stages; EU experience.
Water policy and law: a comparative analysis of European and Ukrainian practices.	Water is the global agenda of the United Nations; integration is a key trend in water management; integrated flood risk management; integrated water resources management by basin principle.
Urban water services: practices of developed European countries.	Water supply systems: circulating water supply; centralized drinking water supply; local or decentralized water supply; cold and hot water supply; Ukrainian experience of normalization of drinking water quality; where can we drink tap water? Experience of EU; drinking water quality standards in Ukraine and EU countries.
Basics of freshwater ecology. The best practices in water purification in the EU member states.	Water policy on the definition of international waters; international water management experience; a sphere of EU influence on water policy formulation; principles of sustainable water management in Ukraine.
Challenges for Ukraine in water security policy and practice due to association with the EU.	The water footprint of the country; the Urban Waste Water Directive; urban wastewater treatment plants; urban sewage treatment technology; the Marine Strategy Directive; the Drinking Water Directive; the Flood Directive; the Nitrate Directive.

A test form of knowledge control was used to assess the completeness of mastering the content of educational material. The test tasks included questions of the reproductive level regarding the key concepts of the training course.

The lower limit of availability is taken as a coefficient of 0.6, which corresponds to a satisfactory level of knowledge. Based on the obtained data, the quantitative processing of the results, which was carried out for each year (the experiment was conducted for three years), and then the average data were derived. It is proved that the selected educational material is quite fully assimilated by students, as evidenced by the average coefficient of 0.85.

To test the strength of knowledge and determine the degree of forgetfulness, a slice of knowledge was performed two weeks after studying the course. The coefficient of knowledge strength was defined as the ratio of the number of elements of knowledge that remained in the memory of students after some time to the sum of the elements of knowledge contained in the test. It is established that more than half of the knowledge remains in the memory of students. It is determined that the degree of forgetfulness is 3–5% of the previous ones. Thus, in the process of forming students' knowledge, the tendency to increase their educational activity, interest in carrying out independent scientific research, in expressing original views on environmental issues discussed during classes was determined.

4. Conclusions

In conclusion, the integrated approach to "Water Security" not only improves the quality of professional training but also fosters environmental stewardship. By emphasizing the regional dimension of water problems, this model helps students master the complex international and local dimensions of environmental policy. Future research will focus on improving assessment methodologies for these integrated modules to ensure the continuity of educational objectives in a changing global climate.

Acknowledgments

This research was supported by the Documenting Ukraine Programme of the Institute for Human Sciences in Vienna (IWM).

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