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INTEGRATIVE DIDACTIC MODEL FOR THE FORMATION OF MEDICAL-ECOLOGICAL COMPETENCE IN STUDENTS OF MEDICAL HIGHER EDUCATION INSTITUTIONS (ON THE EXAMPLE OF THE DISCIPLINE “HYGIENE AND MEDICAL ECOLOGY”)

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Abstract: This article addresses the problem of developing medical-ecological competence among medical university students during the study of the discipline “Hygiene and Medical Ecology”. The relevance of the research is driven by the increasing role of environmental factors in the occurrence of diseases and the need to train physicians capable of effectively addressing the challenges of prevention, diagnosis, and population health management under conditions of environmental adversity. The aim of the study is the theoretical substantiation, development, and description of an integrative didactic model for the formation of medical-ecological competence in future doctors. The methodological framework comprises systemic, competency-based, and integrative approaches, as well as the theory of contextual learning. Based on theoretical analysis, the structural components of medical-ecological competence are identified: motivational-value, cognitive, activity-practical, and reflexive-evaluative. The developed model includes target, content, procedural, and outcome-assessment blocks, united by integrative connections. The procedural block proposes active and interactive teaching methods (problem-based learning, case method, project activities, “Quartet-block” technology, collaborative learning), as well as the possibilities of the digital educational environment. The model was tested in the educational process and demonstrated its effectiveness in increasing the level of medical-ecological competence formation. The practical significance of the work lies in the possibility of using the developed model to improve the teaching of hygiene and environmental disciplines in medical universities.

Keywords: medical-ecological competence, integrative didactic model, medical university students, hygiene and medical ecology, competency-based approach, active teaching methods.

INTRODUCTION

The modern stage of healthcare development is characterized by a paradigm shift from a curative to a preventive orientation. In this context, the role of environmental factors in the formation of population health is increasing. According to the World Health Organization, about 24% of the global disease burden is attributable to modifiable environmental factors, and in children this proportion reaches 26%. Climate change, pollution of atmospheric air, water, soil, chemical and biological contamination of food products, and other environmental stressors create new challenges for medical science and practice. The physician of the 21st century must not only possess clinical skills but also be able to assess environmental risks, interpret the results of hygienic studies, and effectively implement preventive measures at the individual and population levels.

This requirement actualizes the need to form a new integrative quality in future doctors – medical-ecological competence. This concept goes beyond the traditional framework of hygienic knowledge; it implies the ability to holistically perceive the relationships between environmental factors and human health, to apply interdisciplinary knowledge in the field of ecology, hygiene,



epidemiology, and clinical disciplines for solving professional problems, and to actively participate in ensuring environmental safety and promoting a healthy lifestyle.

In the system of higher medical education of the Republic of Uzbekistan, the discipline “Hygiene and Medical Ecology” plays a key role in the formation of this competence. However, traditional teaching methods, based mainly on the transfer of normative knowledge, do not fully ensure the development of the integrative abilities and practical skills necessary for a modern doctor. There is a need to search for new didactic approaches that allow the integration of knowledge from various disciplines, the activation of students’ cognitive activity, and the orientation of the educational process towards the formation of professional competencies.

The purpose of this study is to theoretically substantiate, develop, and experimentally test an integrative didactic model for the formation of medical-ecological competence in students of medical higher education institutions using the example of the discipline “Hygiene and Medical Ecology”.

LITERATURE REVIEW

The theoretical basis of the study includes several key scientific areas.

First, the concept of competence and competency-based approach in professional education has been developed in the works of I.A. Zimnyaya, A.V. Khutorskoy, V.I. Baidenko, and others. In medical education, the competency-based approach is reflected in international standards (CanMEDS, ACGME), where the role of “health advocate” is highlighted, which directly correlates with medical-ecological competence. In the context of domestic pedagogical science, the development of competency-based approaches in medical education is considered in the works of U. Inoyatov, U. Begimqulov, R.G. Isyanov, G.B. Umarova, and others.

Second, the issues of environmental and hygienic training of future doctors are presented in the studies of Yu.P. Pivovarov, N.V. Zilber, and others. However, most works focus on the content of training and the formation of specific knowledge, while the integrative nature of medical-ecological competence remains insufficiently studied.

Third, the integration of knowledge in medical education is the subject of research by both domestic and foreign scientists. Interdisciplinary integration is considered as a mechanism for the formation of a holistic professional worldview and the ability to solve complex clinical problems. In the works of S.N. Dalimova, N. Kamolova, O.A. Abrorov, F.Kh. Inoyatova, the possibilities of integrative approaches in teaching medical disciplines are discussed.

Fourth, the methodological arsenal of the formation of professional competence includes active and interactive teaching methods. Problem-based learning (PBL), case method, project-based learning, collaborative learning, and gamification have proven their effectiveness in developing critical thinking, communication skills, and the ability to apply knowledge in non-standard situations. In the context of hygiene and medical ecology, these methods allow modeling real professional situations related to environmental assessment, risk management, and sanitary education.

Fifth, the digital transformation of education opens up new opportunities for the formation of medical-ecological competence. Electronic information and educational resources, virtual laboratories, interactive simulators, and platforms for collaborative work make it possible to visualize complex environmental processes, simulate situations, and organize independent work of students.

An analysis of the literature shows that despite the presence of individual works on the formation of hygienic competence and the use of integrative approaches in medical education, there is currently no holistic didactic model specifically aimed at the formation of medical-ecological competence, taking into account the specifics of the discipline “Hygiene and



Medical Ecology” and modern educational technologies. This determines the relevance and novelty of the present study.

METHODOLOGY

The methodological basis of the study is formed by the following approaches:

Systemic approach: allows us to consider the process of forming medical-ecological competence as a holistic system consisting of interconnected elements (goals, content, methods, forms, means, results).

Competency-based approach: focuses on the result of education – the formation of a complex integrative quality that ensures the readiness of a graduate to perform professional activities.

Integrative approach: ensures the unification of knowledge from various disciplines (ecology, hygiene, clinical subjects) and the combination of theoretical and practical components of training.

Contextual learning theory (A.A. Verbitsky): substantiates the need to simulate subject and social content of future professional activity in the educational process.

The research was carried out in three stages:

Theoretical-analytical stage (2023- 2024) analysis of philosophical, pedagogical, psychological, and methodological literature on the research problem; determination of the conceptual apparatus; development of the structural components of medical-ecological competence; theoretical modeling.

Experimental stage (2024- 2025) testing of the developed integrative didactic model in the educational process of the Department of Preventive Medicine Foundations of Andijan State Medical Institute. The experiment involved 160 students of the Faculty of Medicine, divided into experimental (n=80) and control (n=80) groups. In the experimental group, training was conducted according to the developed model; in the control group, traditional teaching methods were used.

Analytical-generalizing stage (2025- 2026) processing of experimental results, statistical analysis, formulation of conclusions and recommendations.

Research methods: theoretical analysis, modeling, pedagogical experiment, testing, questionnaires, observation, methods of mathematical statistics (Student’s t-test, Pearson’s chi-squared test).

RESULTS

As a result of theoretical analysis, the concept of “medical-ecological competence of a future doctor” is defined as an integrative professional-personal characteristic that reflects the readiness and ability to identify, evaluate, and manage environmental factors affecting human health; to apply knowledge and skills from the fields of hygiene, ecology, and clinical disciplines in professional activities; to carry out preventive and sanitary-educational work based on an understanding of the relationship between the state of the environment and public health.

The structure of medical- ecological competence includes four interrelated components (Table 1).

Table 1. Structural Components of Medical- Ecological Competence of a Future Doctor

Component	Content	Formed Elements
Motivational-Value	Awareness of the value of health, the importance of prevention, formation of professional interest in environmental and hygienic problems	Understanding of the social significance of medical-ecological activities, personal attitude to a healthy lifestyle, readiness to implement environmental measures, professional self-determination



Cognitive	System of fundamental knowledge about the environment, the mechanism of the impact of environmental factors on the body, methods of assessment, hygienic regulation	Knowledge of general and medical ecology, general and private hygiene, epidemiology, sanitary legislation, methods of hygienic research, principles of environmental risk assessment
Activity- Practical	Ability to apply the acquired knowledge in practical activities	Skills of hygienic assessment of environmental objects (air, water, soil, food), skills of conducting sanitary supervision, skills of organizing and conducting sanitary and educational work, skills of using devices and equipment for environmental monitoring
Reflexive- Evaluative	Ability to analyze one's own activities, the need for self-education and professional improvement	Self-assessment of the level of competence, ability to identify gaps in knowledge and skills, critical analysis of decisions made, orientation towards continuous professional development

Based on the identified structure and factors of formation, an integrative didactic model was developed (Figure 1). The model consists of four interconnected blocks: target, content, procedural, and outcome- assessment.

[Description of the model: The target block reflects the social order, the goal of forming medical-ecological competence, and the tasks. The content block includes the basic content of the discipline “Hygiene and Medical Ecology” integrated with knowledge from clinical disciplines (therapy, pediatrics, infectious diseases, etc.), environmental disciplines, and public health. The procedural block contains methods, forms, and means of teaching, including active and interactive learning technologies, digital tools. The outcome-assessment block includes criteria, indicators, levels of competence formation, and diagnostic tools.]

Table 2. Integrative Didactic Model for the Formation of Medical-Ecological Competence

Block	Components	Implementation Features
Target	Social order: training of a competitive specialist ready for professional activity in the field of prevention and environmental risk management	Goal: formation of medical-ecological competence of future doctors; Tasks: development of motivation, assimilation of knowledge, formation of skills, development of reflective abilities
Content	Integration of the discipline “Hygiene and Medical Ecology” with clinical disciplines (therapy, pediatrics, obstetrics, surgery) and public health disciplines	Sections: general hygiene, municipal hygiene, food hygiene, occupational hygiene, radiation hygiene, medical ecology, environmental epidemiology. Integration nodes: “Environment and health of children”, “Occupational risks in different industries”, “Hygienic aspects of infectious diseases”, “Environmental factors in the development of non-communicable diseases”
Procedural	Active and interactive learning methods; forms of organization; digital tools	Methods: problem-based learning, case method, project-based learning, collaborative learning, “Quartet-block” technology,



		role-playing and business games, discussion, brainstorming. Forms: lectures with elements of dialogue, practical classes with analysis of specific situations, independent work, educational practice, research work. Means: multimedia presentations, video materials, electronic information and educational resources, virtual simulators, interactive tasks
Outcome-Assessment	Criteria: motivational- value, cognitive, activity- practical, reflexive- evaluative; levels: reproductive, productive, creative	Diagnostic tools: observation, testing, questionnaires, analysis of case solutions, evaluation of project activities, portfolio, self- assessment

To test the effectiveness of the developed model, a pedagogical experiment was conducted. In the experimental group, training in the discipline “Hygiene and Medical Ecology” was carried out using the proposed integrative didactic model; in the control group, traditional teaching methods were used. The results of the assessment of the level of medical- ecological competence formation before and after the experiment are presented in Table 3.

Table 3. Comparative Results of the Formation of Medical-Ecological Competence in the Experimental and Control Groups (in %) *

Level	Experimental Group (n=80)		Control Group (n=80)	
	Pre-experiment	Post-experiment	Pre-experiment	Post-experiment
Reproductive	58.7	18.4	60.0	46.2
Productive	35.0	52.8	32.5	41.3
Creative	6.3	28.8	7.5	12.5

Statistical processing using Student’s t-test showed significant differences between the results of the experimental and control groups after the experiment ($t = 4.72$, $p < 0.01$). In the experimental group, the proportion of students with a productive and creative level of competence increased by 40.3%, while in the control group the increase was 14.2%.

DISCUSSION

The results of the study confirm the effectiveness of the developed integrative didactic model for the formation of medical-ecological competence. The increase in the indicators in the experimental group compared to the control group can be explained by several factors.

First, the integration of the content of the discipline “Hygiene and Medical Ecology” with clinical disciplines contributed to the formation of a holistic perception of professional tasks. Students began to see not just isolated hygienic norms, but their connection with specific clinical situations, with the processes of diagnosis, treatment, and rehabilitation. This is consistent with the theory of contextual learning, which states that the educational material is assimilated more deeply and becomes personally significant when it is presented in a professional context.

Second, the use of active and interactive learning methods contributed to the activation of cognitive activity, the development of critical thinking, and the ability to work in a team. Methods such as case analysis based on real environmental and hygienic situations, project activities (development of projects for sanitary and educational work, improvement of the environment), business games (simulation of the work of a sanitary and epidemiological service) allowed students to immerse themselves in the context of future professional activity, to feel responsible for decisions made.



The “Quartet-block” technology deserves special mention, which provided a combination of four blocks of information: theoretical (basic concepts and patterns), practical (methods of hygienic assessment), analytical (analysis of specific situations), and reflexive (self-assessment of the formed skills). This structure contributed to the systematic assimilation of knowledge and the formation of the ability to apply it in practice.

Third, the digital educational environment, including electronic information and educational resources, virtual simulators, and interactive tasks, provided opportunities for independent work, visual presentation of complex environmental processes (for example, modeling the dispersion of pollutants in the atmosphere), and the development of skills in using modern information technologies for hygienic assessment. At the same time, digital tools did not replace live communication and interaction with the teacher, but organically complemented them, which is consistent with the principle of reasonable digitalization.

The results obtained allow us to conclude that the developed integrative didactic model can be successfully used in the teaching of hygiene and environmental disciplines in medical universities. The model meets the modern requirements for the training of doctors who are able to work in conditions of increasing environmental pressure and implement preventive measures effectively.

CONCLUSION

The problem of forming medical-ecological competence in students of medical higher education institutions is relevant in the context of the transition to a preventive model of healthcare and the aggravation of environmental problems. In this study, the concept of medical-ecological competence is clarified as an integrative professional-personal characteristic that includes motivational-value, cognitive, activity-practical, and reflexive-evaluative components.

The developed integrative didactic model for the formation of medical-ecological competence includes target, content, procedural, and outcome-assessment blocks, united by integration links. The procedural block implements active and interactive teaching methods, including problem-based learning, case method, project activities, “Quartet-block” technology, collaborative learning, and digital learning tools.

Experimental testing of the model in the educational process of the Department of Preventive Medicine Foundations of Andijan State Medical Institute confirmed its effectiveness: in the experimental group, the proportion of students with a productive and creative level of medical-ecological competence increased significantly compared to the control group.

The practical significance of the study lies in the possibility of using the developed model to improve the teaching of the discipline “Hygiene and Medical Ecology” and related disciplines, as well as for the development of educational and methodological complexes, including those based on digital technologies.

Prospects for further research are related to the adaptation of the model for the conditions of distance and blended learning, the development of a system for monitoring the formation of medical-ecological competence at all stages of medical education, and the study of the influence of the model on the subsequent professional activity of graduates.

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