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PROBLEM-BASED LEARNING TECHNOLOGY AS A MEANS OF ACTIVATING THE COGNITIVE ACTIVITY OF LEARNERS

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Abstract

Relevance: In the context of the full-scale war caused by the armed aggression of the Russian Federation, the Ukrainian education system is undergoing profound transformations, particularly in the sphere of training future specialists for economic recovery and sustainable development. The task of forming learners capable of critical thinking, independent action, making informed decisions, and adapting to rapidly changing conditions is gaining particular importance. In this context, the implementation of learning technologies that meet the challenges of Industry 4.0 and promote the activation of cognitive activity becomes relevant. Problem-based learning, focused on setting learning tasks that require search and analytical work, proves to be an effective means of developing professional-critical competencies of vocational pre-higher education learners.

*Aim***:** To investigate problem-based learning technology as a tool for activating the cognitive activity of vocational pre-higher education learners in the context of preparing for professional activities in conditions of digital transformation and societal challenges.

*Methods***:** Theoretical methods (analysis and generalization – for processing scientific and pedagogical sources on problem-based learning, identifying leading approaches to its organization); comparative analysis – for studying modern pedagogical practices in vocational pre-higher education institutions, comparing traditional and innovative teaching models; systematization of empirical data from educational practice – for substantiating the conditions for the effective use of problem-based learning, considering the needs of learners and the realities of martial law.

*Results***:** It has been proven that the use of problem-based learning technology ensures an increase in motivational interest, the development of reflective thinking, and the formation of the ability to independently solve educational and production tasks. The structural components of the technology are analyzed, and the conditions for its effective application in the training of new generation specialists are determined.

*Conclusions***:** Problem-based learning contributes to the realization of the educational goal in the field of vocational pre-higher education – the training of competitive, mobile, critically thinking specialists capable of acting effectively in the conditions of Industry 4.0 and taking an active part in the restoration of the state during wartime and post-war transformations.

Keywords: *pedagogical technologies, problem-based learning, cognitive activity, professional pre-higher education, critical thinking, Industry 4.0.*

Introduction. In the contemporary conditions of the educational environment's transformation, driven by digitalization, automation, and changes in the labor market, the reorientation of educational technologies toward the development of students' cognitive activity and independence is becoming particularly relevant (Kremen, 2021). Institutions of professional pre-higher education are called upon to provide not only professional training but also to cultivate graduates' ability to act effectively in the context of Industry 4.0, where competencies related to analytical thinking, flexibility, and the ability to solve complex production and organizational tasks are of special importance. At the same time, traditional teaching approaches, which focus mainly on the reproductive recall of knowledge, are increasingly failing to meet the needs of modern production and the knowledge society. Consequently, there is a growing need to implement educational technologies that would activate students' cognitive activity, promote the development of critical thinking, argumentation skills, reflection, and independent decision-making (Pavlenko, 2013; Ihnatenko, 2015). One of the effective pedagogical technologies capable of achieving the aforementioned goals is problem-based learning. Its essence lies in creating problem situations that require inquiry-based activities, hypothesizing, and justifying solution options. This approach contributes to the formation of both general and professional competencies in students, which are necessary for productive professional activity in a high-tech environment. Sources. The problem of activating students' cognitive activity within formal education has been a subject of long-standing scientific interest in both Ukrainian and foreign pedagogy. Recent years have been marked by increased attention to interactive technologies that foster the development of critical thinking, independence, and the ability to analyze information under unpredictable external circumstances, particularly war and digital transformation. In this context, the conceptual approaches to organizing the educational process proposed by O. Humennyi and O. Fedorenko are a valuable contribution to the development of effective pedagogical strategies aimed at shaping an active, responsible, and intellectually mobile student (Humennyi & Fedorenko, 2023). Research indicates that problem-based learning has the potential not only to activate mental activity but also to promote the formation of transversal competencies necessary for work in the Industry 4.0 era. Pedagogical developments of recent years confirm the effectiveness of using the problem-based approach in institutions of professional pre-higher education as a means of forming a reflective, responsible, and adaptive personality (Lementarenko, 2012). As a result of reviewing contemporary pedagogical research (Pukhovska, L., 2011; Tesliuk, Luzan, & Shovkun, 2010; Karpushyna, 2018), it has been established that problem-based learning has significant potential for activating cognitive activity and forming transversal competencies necessary for effective professional activity in the context of Industry 4.0. In the practice of professional pre-higher education institutions, this technology has proven its effectiveness in developing critical thinking, reflexivity, responsibility, and adaptability. The author shares the researchers' position, emphasizing the expediency of systematically implementing the problem-based approach in the educational process as one that meets the modern challenges of digital transformation and the state of war in Ukraine. As the next stage of this direction, the integration of problem-based learning with elements of STEM education, project activities, and gamification is proposed for the comprehensive development of students' professional agency. Separate studies focus on the methodological aspects of implementing problem-based learning, particularly on the development of learning situations that involve inquiry-based activities, analytical information processing, and the formulation of substantiated conclusions (Filatova, 2021). These works emphasize the didactic mechanisms for creating an intellectually enriched educational environment in which students not only reproduce knowledge but

also actively participate in its creation. The author of this article supports such a methodological orientation, viewing it as an effective tool for forming independent thinking, information literacy, and the ability to make decisions in a real professional environment. Research also highlights the need to update the training of pedagogical staff for the implementation of active-type technologies in the educational process, which is especially important in the context of reforming professional pre-higher education. This refers to the need for developing modern methodological competencies in teachers, the ability to design a dynamic learning environment, and the use of tools aimed at developing students' cognitive activity. The author of the article shares the position on the relevance of teachers' professional growth as a prerequisite for the quality implementation of innovative educational technologies, including problem-based learning, into the practice of training future specialists. At the same time, the specifics of implementing problem-based learning technology specifically in professional pre-higher education under wartime conditions, considering the challenges of digitalization, the growing autonomy of students, and the need to develop their professional agency, have not been sufficiently covered. In this regard, this scientific inquiry is focused on studying the potential of problem-based learning as a factor in forming the cognitive activity of students in colleges and vocational schools that prepare future specialists for the innovative recovery of the country. The purpose of the article is the theoretical substantiation and methodological analysis of problem-based learning technology as an effective means of activating the cognitive activity of students in professional pre-higher education in the context of training competitive specialists capable of acting under the conditions of digital transformation, the challenges of Industry 4.0, and social instability caused by the war in Ukraine. Within the scope of the research, the tasks were to analyze the degree of scientific development of the problem, to identify the potential of problem-based learning for the development of transversal competencies, and also to outline the conditions for its effective implementation in the educational process of professional pre-higher education institutions. Methods. Theoretical methods were used in the research process, including the analysis and generalization of scientific and pedagogical sources on the problem of problem-based learning, which allowed for the determination of leading approaches to its organization and its pedagogical potential in professional education. A comparative analysis of modern pedagogical practices in institutions of professional pre-higher education was also used, which made it possible to compare traditional and innovative teaching models. The method of systematizing empirical data from educational practice was applied to substantiate the conditions for the effective use of problem-based learning, taking into account the needs of students and the realities of the state of war. Results and Discussion. Problem-based learning technology is considered one of the most effective means of activating students' cognitive activity, especially at the professional pre-higher level. It belongs to the group of active-type educational technologies aimed at developing a high level of cognitive tension, research skills, and the ability of students to independently construct knowledge. Its didactic essence lies in organizing the learning process in such a way that the teacher does not simply transmit ready-made information but creates situations of intellectual complexity for students that require searching for non-standard solutions, logical analysis, synthesis, evaluation, and reflection. The central structural unit of this technology is the problem-based task—a learning situation that involves a contradiction, uncertainty, or informational insufficiency that the student must overcome independently or in the process of group interaction. In pedagogical practice, such a situation stimulates intellectual activity, mobilizes the individual's internal resources, and encourages the independent search for knowledge. The author has developed a model (Fig. 1) that reflects the logic of implementing problem-based learning technology as a means of activating the cognitive activity of students in professional pre-higher education. Its goal is to stimulate intellectual development, form the ability for independent thinking, and make decisions under conditions of uncertainty. The objective of the model is to prepare a student capable of effectively acting in professional situations that meet the challenges of digital transformation and the requirements of Industry 4.0. Five main stages are

distinguished in the structure of the model: 1. Creating a problem situation (problem awareness); 2. Actualization of prior knowledge and search for solution directions; 3. Formulation of hypotheses and solution options; 4. Analysis, verification of hypotheses, and justification of solutions; 5. Reflection and generalization of the experience gained (Fig. 1). These stages are implemented in conjunction through the functional actions of the teacher (facilitation, moderation, stimulation of cognitive interest) and the active engagement of the student, which includes analysis, critical thinking, idea formulation, and the application of knowledge in new situations. The objectives of the technology are to create a problem-based learning environment, activate inquiry-based activities, and form skills of analysis, hypothetical thinking, and reflection. The expected results of implementing PBL include the development of critical thinking, an increase in cognitive motivation, the formation of research skills, and an increased readiness for professional activity in complex conditions. The context for the application of the model is professional pre-higher education, oriented towards training highly qualified specialists for fields undergoing rapid changes, such as agroengineering, veterinary medicine, and electric power engineering, in accordance with labor market demands and the conditions of wartime and post-war recovery of the country.

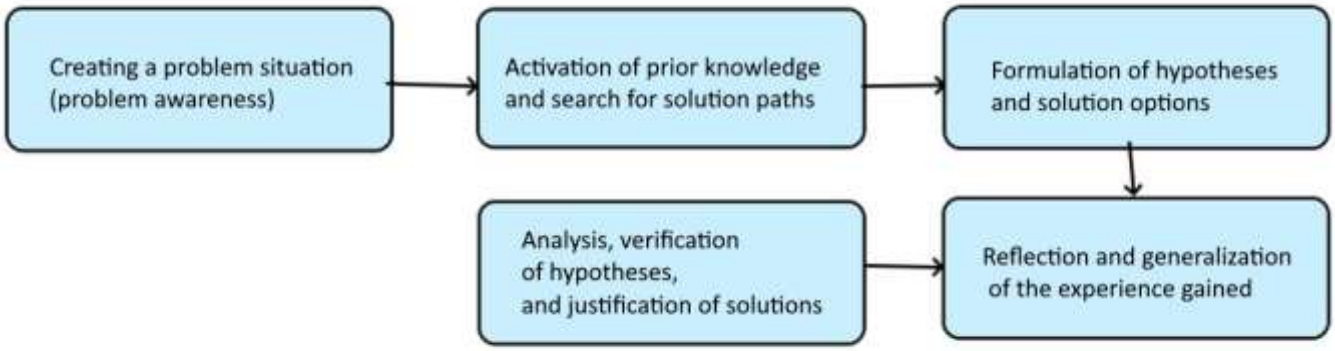

Figure 1. Model of problem-based learning technology

In this context, the role of the teacher is transformed: they act not as a source of ready-made knowledge, but as a facilitator and organizer of cognitive activity, who creates conditions for intellectual growth and internal motivation. At the same time, the student acts as an active subject of the educational process, capable of independently establishing logical connections, drawing conclusions, and applying knowledge in new situations. Scientific sources (Humennyi & Fedorenko, 2023; Kankovskyi, 2009) testify that problem-based learning ensures: the formation of critical and creative thinking; the development of research skills; an increase in the level of motivational engagement in the learning process; the ability to make informed decisions under uncertainty; the integration of knowledge from different subject areas. In professional pre-higher education, this technology is particularly effective because it combines the mastery of theoretical material with the solution of practice-oriented tasks. The use of educational case studies, situational modeling, and interdisciplinary problem-based modules contributes to the formation of professional readiness, flexibility of thought, and the ability to act responsibly in the rapidly changing environment of Industry 4.0. That is why it is advisable to consider problem-based learning as a leading means of developing the intellectual potential of students, their cognitive independence, and competitiveness in the modern labor market. The study examined the implementation of problem-based learning technology in the educational process of VSP "Nemishaieve Vocational College of NUBiP of Ukraine," one of the leading institutions of professional pre-higher education in the agricultural sector, which trains specialists for the agro-industrial complex, veterinary medicine, agroengineering, ecology, and forestry. An analysis of the college's internal educational practices,

particularly the implementation of complex production and technological tasks in the form of situational modeling, showed that the use of a problem-based approach contributes not only to an increase in motivation for learning but also to a deeper engagement of students in the process of analyzing professional tasks. In the transition to Industry 4.0 technologies, where automated systems, digital platforms, precision agriculture, and biotechnologies play a key role, not only knowledge but also competencies in critical thinking, adaptability, and solving non-standard production situations become necessary. Problem-based learning, as proven by the results of the analysis of the college's practices, provides an appropriate level of cognitive tension and creates conditions for the formation of an analytical style of thinking, which is crucial for specialists in the agricultural sector in the context of digital transformation. The study of the implementation of problem-based learning technology in the educational process of VSP "Nemishaieve Vocational College of NUBiP of Ukraine" analyzed its application in a number of disciplines, including:

1. Agroengineering: students solved practical tasks on the operation and technical maintenance of agricultural machinery, which contributed to the development of technical thinking and skills for solving real production problems. Within the study of the discipline "Operation and Repair of Agricultural Machinery," students were involved in solving problem situations that were modeled by analogy with real production conditions. Example: Case 1. Identifying malfunctions in the hydraulic system of the MTZ-82 tractor. Students were asked to model a situation where unstable operation of the mounted mechanism is detected during fieldwork. The students independently analyzed technical documentation, diagnosed malfunctions, and proposed optimal ways to eliminate the breakdown, taking into account available resources. Case 2. Developing a technological map for the technical maintenance of the SZ-3.6 seed drill. The task was to analyze the maintenance regulations according to the factory instructions, assess the operating conditions on specific soil, and create a step-by-step maintenance plan with the selection of appropriate tools and consumables. The work was carried out in groups with a subsequent presentation of the solutions. Case 3. Determining the economic feasibility of replacing a unit on the "Niva SK-5" combine harvester. Students analyzed the wear conditions of the header, compared options for major repair versus replacement with a new unit, calculated costs, and made a decision based on economic efficiency. The task was complicated by the fact that the constraints of wartime conditions—availability of supplies, logistics, and repair facilities—had to be taken into account. The use of such cases in problem-based learning allowed for the formation of a systemic vision of production processes in students, combined theoretical knowledge with practical skills, and developed the ability to make informed decisions in a real professional context.

Table 1

DYNAMICS OF CHANGES IN INDICATORS OF EDUCATIONAL ACTIVITY OF STUDENTS IN THE DISCIPLINE "AGROENGINEERING" BEFORE AND AFTER THE IMPLEMENTATION OF PROBLEM-BASED LEARNING TECHNOLOGY

Indicator	**Before implementation**	**After implementation**
Average level of technical thinking (on a 5-point scale)	3.1	4.3
Independence in solving production tasks (%)	58.0	83.0
Quality of practical work performance	65.0	89.0
Motivation for learning (on a 5-point scale)	3.4	4.6
Academic performance (average grade in the discipline)	3.2	4.4

The results of the comparative analysis (Table 1) show a positive dynamic for all evaluated indicators after the implementation of problem-based learning in the "Agroengineering" discipline.

The most pronounced growth is observed in the sphere of qualitative characteristics of cognitive activity and professional thinking. In particular, the average level of technical thinking increased from 3.1 to 4.3 points (a growth of 38.7%), which indicates a significant deepening of understanding of technological processes and the ability to critically evaluate them. The indicator of independence in solving production tasks increased from 58% to 83%, i.e., by almost a third. This confirms an increase in the level of initiative, decision-making ability, and the readiness of students to act autonomously within the framework of modeling professional situations. The quality of practical work performance increased from 65% to 89%, which indicates an increase not only in the motivational but also in the operational component of educational activity—students not only understand the material better but also apply it more effectively in specific practice-oriented tasks. The motivation for learning indicator also showed significant improvement—from 3.4 to 4.6 points, which indicates a strengthening of students' internal interest in the learning process and an increase in their emotional and value-based attitude towards professional training. The final level of academic performance (in the form of the average grade) increased from 3.2 to 4.4, which confirms the overall improvement in the results of mastering the educational material. The empirical data confirm that the implementation of problem-based learning in the educational process positively influences the development of cognitive, motivational, and practical components of the educational activity of professional pre-higher education students in the field of agroengineering. 2. Veterinary Medicine: the use of case methods for analyzing clinical cases allowed students to develop clinical reasoning and make informed decisions under conditions of uncertainty. Within the study of the effectiveness of problem-based learning in the educational process of Nemishaieve Vocational College of NUBiP of Ukraine, special attention was paid to the specialty "Veterinary Medicine," which requires students to have not only knowledge of the theoretical foundations of anatomy, pathology, and pharmacology but also a high level of professional reflection, rapid decision-making in clinical situations, and the ability to act under uncertainty. Taking into account the specifics of professional training, case methods were integrated into the educational process as one of the forms of implementing problem-based learning technology. Students worked with clinical cases that modeled real veterinary situations—acute mastitis in a cow, postpartum paresis, intracellular parasites in dogs, etc. They had to independently analyze the symptomatology, make a diagnosis, justify their actions, and develop a treatment plan. This approach stimulated the development of clinical reasoning, formed the ability for a rapid and well-founded response, and also contributed to an awareness of responsibility for the decisions made. To evaluate the results of implementing the case methods, the changes in the main indicators of students' educational activity were analyzed. The dynamics of these changes are shown in (Fig. 2).

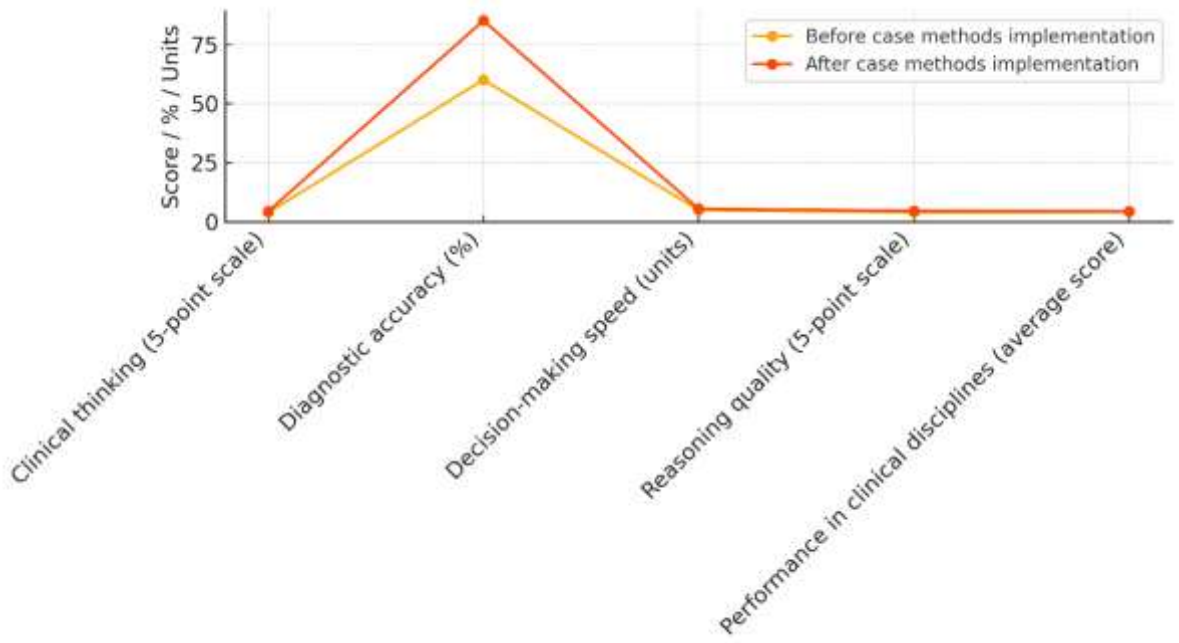

Figure 2. Dynamics of indicators of educational activity in veterinary medicine

Analysis of the data presented in Fig. 2 demonstrates a significant improvement in the key indicators of students' educational activity after the implementation of case methods within veterinary disciplines. The most indicative is the growth in the level of clinical reasoning—from 3.2 to 4.5 points, which testifies to the development of students' ability to comprehensively understand symptomatology, construct a diagnostic hypothesis, and justify treatment decisions. The diagnostic accuracy indicator increased from 60% to 85%, which can be attributed to a more systematic approach to analyzing clinical data, the formation of analytical thinking, and a better understanding of the logic of the veterinary process. At the same time, the speed of decision-making almost doubled (from 2.5 to 4.0 arbitrary units), indicating an increase in students' confidence in their own knowledge and skills to apply them in modeled real situations. An improvement in the justification of decisions made is also observed—from 3.3 to 4.6 points, which demonstrates not only the mechanical assimilation of information but also the formation of the logic of professional reasoning. The final academic performance indicator in clinical disciplines increased from 3.4 to 4.5 points, confirming an overall increase in the quality of educational achievements. The positive dynamics of all analyzed parameters show that the use of case methods as a form of problem-based learning in veterinary education is an effective tool for forming professionally important competencies, which is particularly relevant in the context of the growing complexity and responsibility of veterinary practice in the 21st century. 3. Electric Power Engineering, Electrical Engineering, and Electromechanics: the application of a problem-based approach to the study of electrical systems contributed to a deeper understanding of their operating principles and the development of design skills, specifically—when studying topics related to the construction of control circuits for asynchronous motors, students were given problem tasks that required independent analysis of technical conditions, selection of equipment, calculation of network parameters, and creation of schematic electrical diagrams. Some cases were based on real production situations, for example: developing an emergency power supply system for a farm or optimizing greenhouse lighting with energy efficiency in mind. The use of this approach provided for the interdisciplinary integration of knowledge from electrical engineering, basics of automation, energy conservation, and labor protection. Students not only better assimilated the theoretical material but also formed practical skills in project thinking, planning, and the technical and economic justification of the proposed solutions. This became

the foundation for the development of an engineering style of thinking, oriented towards the real challenges of Industry 4.0. The application of problem-based learning in these disciplines positively influenced the formation of students' critical thinking, the ability to make independent decisions, and adaptation to changing working conditions, which are key competencies in the context of Industry 4.0. For the further improvement of the educational process, it is advisable to develop methodological recommendations for the integration of problem-based learning into other disciplines and to ensure the training of pedagogical staff for the application of this technology. Conclusions. The results of the conducted research confirmed the achievement of the set goal—problem-based learning technology proved to be an effective tool for activating the cognitive activity of students in professional pre-higher education under the conditions of digital transformation and the growing professional challenges associated with social instability and the needs of Industry 4.0. Based on theoretical analysis and empirical observations, it was established that the implementation of a problem-based approach in the educational process contributes to the development of a number of transversal competencies, including: critical and clinical thinking, the ability to make independent decisions, the justification of actions, analytical skills, and practical readiness to solve professional situations. The application of problem-based learning in specialties such as agroengineering, veterinary medicine, electric power engineering, and electromechanics made it possible to combine the assimilation of theoretical knowledge with the modeling of real cases, which increased the level of motivation, academic performance, and practical readiness of students for work in high-tech production environments. Promising directions for further scientific research include the development of methodological models for integrating problem-based learning with other active educational technologies, particularly STEM education, elements of gamification, dual education, and digital simulation. Also requiring in-depth study are the issues of professional training for pedagogical staff to implement problem-based learning in a blended educational environment and with remote access, which is particularly relevant during the period of martial law.

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ТЕХНОЛОГІЯ ПРОБЛЕМНОГО НАВЧАННЯ ЯК ЗАСІБ АКТИВІЗАЦІЇ ПІЗНАВАЛЬНОЇ ДІЯЛЬНОСТІ ЗДОБУВАЧІВ ОСВІТИ

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Реферат:

Актуальність: в умовах повномасштабної війни, спричиненої збройною агресією російської федерації, українська система освіти зазнає глибоких трансформацій, зокрема у сфері підготовки майбутніх фахівців для економіки відновлення та сталого розвитку; особливої ваги набуває завдання формування здобувачів освіти, здатних мислити критично, діяти самостійно, ухвалювати обґрунтовані рішення та адаптуватися до швидкозмінних умов; у цьому контексті актуальним стає впровадження технологій навчання, які відповідають

викликам Індустрії 4.0 та сприяють активізації пізнавальної діяльності; проблемне навчання, орієнтоване на постановку навчальних завдань, що вимагають пошукової та аналітичної роботи, виявляється ефективним засобом розвитку професійно-критичних компетентностей здобувачів фахової передвищої освіти.

Мета – дослідити технологію проблемного навчання як інструмент активізації пізнавальної діяльності здобувачів фахової передвищої освіти в контексті підготовки до професійної діяльності в умовах цифрової трансформації та суспільних викликів.

Методи: теоретичні (аналіз і узагальнення – для опрацювання науково-педагогічних джерел з проблеми проблемного навчання, визначення провідних підходів до його організації); порівняльний аналіз – для вивчення сучасних педагогічних практик у закладах фахової передвищої освіти, зіставлення традиційних та інноваційних моделей викладання; систематизації емпіричних даних з освітньої практики – для обґрунтування умов ефективного використання проблемного навчання з урахуванням потреб здобувачів освіти та реалій воєнного стану.

Результати: доведено, що використання технології проблемного навчання забезпечує зростання мотиваційної зацікавленості, розвиток рефлексивного мислення та формування здатності до самостійного вирішення навчальних і виробничих завдань; проаналізовано структурні компоненти технології, визначено умови її ефективного застосування у підготовці фахівців нової генерації.

Висновки: проблемне навчання сприяє реалізації освітньої мети у сфері фахової передвищої освіти – підготовці конкурентоздатного, мобільного, критично мислячого фахівця, здатного діяти ефективно в умовах Індустрії 4.0 та брати активну участь у відновленні держави в період воєнних і післявоєнних трансформацій.

Ключові слова: *педагогічні технології, проблемне навчання, пізнавальна активність, фахова передвища освіта, критичне мислення, Індустрія 4.0.*

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