PROFESSIONAL EDUCATION:
METHODOLOGY, THEORY AND TECHNOLOGIES
Journal homepage: https://profedu.com.ua/en
Vol. 12, No. 1, 2026, 72-86
ISSN 2415-3729;
e-ISSN 2415-3737

Article's History: Received: 18.11.2025 Revised: 06.04.2026 Accepted: 12.05.2026 Published: 19.06.2026

UDC 378.147:004.8:377
DOI: 10.69587/pemtt/1.2026.72

Contemporary approaches to the implementation of digital technologies (artificial intelligence) in the professional training system for teaching staff of vocational education institutions

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■ **Abstract.** The study aimed to define the prospects, prerequisites, and limitations of using artificial intelligence technologies to train the teaching staff of vocational education institutions, using the method of analysis of regulatory documents and educational programmes. The study was carried out using regulatory and documentary analysis, content analysis of educational programmes, and comparative analysis of educational practices. Results revealed that the theoretical and regulatory foundation for vocational teaching staff training was a prerequisite for the use of digital technologies, but it did not provide enough specifics about the implementation of artificial intelligence. The analysed educational programmes included digital technologies as a direction, a means of education, and a component of professional activities, but not the use of artificial intelligence as a systemic component of training. Information and communication competence was considered a multidimensional formation of the technical, methodological and organisational components of readiness of teachers, but not full-fledged working with intelligent systems. As a result of the comparison with the best examples of European educational programmes, it was revealed that the integration of artificial intelligence into the system of vocational education was provided in the form of separate modules, separate projects and special state programmes, which ensured the systematic nature. It has been established that the use of artificial intelligence opens up opportunities to expand the didactic potential of professional education in order to implement the provisions on individualisation of education, including automated learning materials development, the introduction of simulations and the use of analytical systems. However, the use of artificial intelligence technologies in professional education is limited by the problems of a legal, methodological, educational and technical nature. The practical significance of the results obtained lies in the possibility of using them to update educational programmes, create educational materials in the context of the use of artificial intelligence, specify the learning outcomes in the aspect of digital competence, as well as to develop a set of methodological materials on the use of artificial intelligence for vocational education educators, specialist subject teachers and industrial training masters

■ **Keywords**: educational programmes; digital competence; regulatory framework; competence; personalisation

■ Introduction

The relevance of the study is determined by the fact that the digital transformation of education is reshaping both the content and organisation of the professional training of teaching staff, particularly for vocational education institutions. Artificial intelligence (AI) technologies are gradually becoming integrated into the educational process, influencing the ways educational content is created, learning outcomes are assessed,

Suggested Citation:
Dobroskok, I., (2026). Contemporary approaches to the implementation of digital technologies (artificial intelligence) in the professional training system for teaching staff of vocational education institutions. *Professional Education: Methodology, Theory and Technologies*, 12(1), 72-86. doi: 10.69587/pemtt/1.2026.72.

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training is individualised, and professional situations are modelled. The research problem lies in the need to determine how artificial intelligence can be integrated into the training of vocational teachers, lecturers of specialised disciplines, and industrial training masters. Examination of this issue is necessary in order to establish whether current standards and educational programmes provide a sufficient basis for the development of digital competence related to the use of AI. It also makes it possible to identify the changes that should be introduced into the content of professional training so that future teaching staff can apply AI safely, methodologically appropriately, and in accordance with the objectives of vocational education.

In scholarly literature, the issue of implementing artificial intelligence in education has been examined in relation to the digitalisation of the educational environment, changes in the role of teachers, and the renewal of approaches to the organisation of learning. One of the leading areas of research concerned the potential of AI for the individualisation of educational trajectories. Intelligent systems were found to enhance the adaptability of learning, optimise the assimilation of educational material, and strengthen interaction among participants in the educational process. In this context, S. Vasylyuk-Zaitseva *et al*. (2023) linked the effectiveness of such changes to teachers' readiness to use digital tools in educational practice. Further development of this issue was associated with the adaptation of the educational process to AI technologies at the systemic level. V. Motorina *et al*. (2025) concluded that intelligent technologies contributed to the transition towards more flexible learning models. Their effectiveness depended on institutional support, digital infrastructure, and methodological provision, which highlighted the organisational dimension of AI implementation.

From the vantage point of the concept Education 4.0, digital and intelligent technologies have been viewed as those that transform the very logic of the educational process. S. Kryshtanovych *et al*. (2025) noted that their introduction had expanded the flexibility and interdisciplinarity of the educational process and its practice-based direction. Especially for vocational education and training, as the competences formed were to be manifested in real or model professional situations. At the same time, the use of AI was accompanied by mixed attitudes among participants in the educational process. S. Dovgyi *et al*. (2024) pointed out that interest in AI among both teachers and students was coupled with worries about academic integrity, credibility of sources, and ethical aspects of the use of AI. This highlighted the importance of developing not only technological but also critical and ethical components of digital competences.

Professional activities of teachers with regard to AI were considered with a view to improving the effectiveness of the educational process. S. Skvortsova *et al*. (2025) showed that AI contributed to the optimisation of educational material preparation and reduced the routine workload of teachers. At the same time, the effectiveness of its use depended on the level of digital competence among teaching staff and their readiness to work with intelligent tools. At the level of broader challenges facing the educational system, AI was regarded as a factor expanding learning opportunities. O. Kletskov & O. Onopriienko (2025) have found that introducing AI could enable personalisation of the educational process, but it also requires changes in regulatory and methodological support. This highlighted the necessity of combining technological solutions with pedagogical principles to guide their use. Particular attention was devoted to AI as a tool for the scientific and educational activities of teachers. A. Bruiaka *et al*. (2025) established that such tools increased productivity, expanded analytical capacities, and contributed to the improvement of educational content. At the same time, teachers were expected to retain responsibility for expert review, editing, and the careful selection of generated materials. In the training of vocational education teachers, the development of creative potential remained an important issue. V. Kovalchuk *et al*. (2024) demonstrated that modern digital technologies promoted the development of flexible thinking, professional initiative, and readiness for innovative activity. In this context, AI could be regarded as a resource for designing educational situations, modelling professional tasks, and developing creative competences.

The broader experience of using digital resources in Ukrainian education demonstrated that the effectiveness of digitalisation depended on the level of teacher training, the availability of resources, and methodological support. O. Ovcharuk *et al*. (2023) established that digital resources contributed to the development of key competences and expanded learning opportunities. This finding was important for understanding AI as a component of the broader digital ecosystem of education. A similar relationship was observed in the context of distance learning. O. Budnyk *et al*. (2021) demonstrated that digital technologies created new opportunities for the training of future teachers while also requiring the adaptation of teaching methods. This corresponded to the logic of AI implementation, as its use involved the renewal of the content, methods, and outcomes of professional training.

An analysis of academic studies on the topic of artificial intelligence use in the educational process was mostly devoted to the issues of general digitalisation or the work of teachers in higher educational institutions. However, there was not enough attention paid to the issue of the use of AI in the system of professional training for the teaching staff of vocational education institutions, considering the specifics of their professional

activity. There was also no correlation between the regulatory, educational programme, and operational conditions of AI use that could form a comprehensive understanding of the problems. Therefore, the study analysed the conditions for the use of artificial intelligence technologies in the system of professional training of teachers for vocational education, as well as the regulatory, content and organisational constraints. To achieve the aim of the study, the following objectives were formulated: to consider the theoretical and regulatory basis for the implementation of digital technologies and artificial intelligence in the system of training teaching staff in vocational education; to analyse the educational programmes for specialty A5 "Vocational education (by specialisation)" in Ukraine and international practice; to identify the opportunities and limitations of integrating artificial intelligence into the training system of the teaching staff of vocational education institutions.

Materials and Methods

The study was conducted as a qualitative, theoretical and analytical examination of regulatory documents, educational programmes, and practices related to the integration of AI into teacher training. Materials were selected according to thematic relevance, regulatory significance, and the presence of provisions concerning digital technologies or AI, while the analysis covered regulatory guidelines, educational programmes, opportunities, and barriers to integration. The empirical basis of the study consisted of regulatory documents, methodological recommendations, international frameworks, educational programmes, and educational initiatives related to the digitalisation of vocational education and the use of AI in teacher training (Ministry of Education and Science of Ukraine, 2019; UNESCO, 2023; Resolution of the Cabinet of Ministers of Ukraine No. 1021, 2024; Order of the Ministry of Education and Science of Ukraine No. 192, 2025). The analysis included three educational programmes in specialty A5 "Vocational Education (Digital Technologies)", published 2021-2025, as well as Ukrainian and international materials concerning the application of AI in education (Educational and Research Institute of Vocational and Pedagogical Studies, Ukrainian Academy of Engineering and Pedagogy, 2021; Ministry of Education and Science of Ukraine & Ministry of Digital Transformation of Ukraine, 2024; Ukrainian State University of Chemical Technology, 2024; Ministry of Education and Science of Ukraine, 2025; Lutsk National Technical University, 2025). The comparative dimension of the study was supported by the initiatives AI VET Project, AI Pioneers, Estonia AI Leap 2025, and materials published by Reuters concerning the preparation of teachers for the use of AI, as these reflected project-based, institutional, and state-level approaches to the integration of intelligent technologies into education (AI Pioneers, n.d.; AI VET Project Consortium, 2025; Education Estonia, 2025; Reuters, 2025).

The research used methods of regulatory and documentary analysis, content analysis, comparative analysis, generalisation and systematisation. The research was performed in three sequential stages: search and selection of sources, grouping of materials based on analytical categories and analysis and synthesis of the obtained results. At the stage of searching and selecting sources, consideration was given to regulatory significance, relevance to the digitalisation of vocational education, and the presence of provisions related to digital competence, AI, or teacher training. Regulatory documents were analysed with regard to the representation of speciality A5, its specialisations, digital competence, and the possibilities for using AI in professional training. Within the framework of the content analysis, educational components, programme learning outcomes, general and professional competences, content modules, and practical skills directly or indirectly related to digital technologies and AI were examined. Particular attention was paid to whether digital technologies were presented as an independent area of training content, a tool for organising learning, or a component of the teacher's future professional activity. Learning outcomes were compared with the technical, pedagogical, ethical, and social dimensions of AI competence presented in international frameworks. This made it possible to determine which aspects of preparation for the use of AI had already been reflected in educational programmes and which required further specification. The comparison of Ukrainian and international approaches was conducted according to the criteria of regulatory definition of AI, the presence of educational modules, practical orientation, methodological support, ethical aspects, staff training, and the relationship between AI and the professional functions of teachers. At the final stage, the results of the analysis were generalised in order to identify the main directions and limitations of AI integration into the training of vocational education teachers. The framework of information and communication competence, together with the functional differentiation of AI use, was developed through structural and functional generalisation and by comparing the professional functions of teachers with scenarios for the application of intelligent technologies.

Results and Discussion

Regulatory guidelines for the digital training of vocational education teachers

The training of teaching staff in vocational educational institutions is proceeding in the conditions of an updated regulatory framework, which integrates the requirements for professional and pedagogical specialisation of a specialist and readiness for digital transformation. The implementation of digital technologies and artificial intelligence in such a system is determined not only

by the technical modernisation of the educational process, but also by changes in the content of professional education and training. Digital tools are becoming an integral component of the professional activity of future teachers in vocational educational institutions, educators of specialised disciplines, and industrial training masters, since they are used in the development of educational courses, organisation of practical training, creation of educational materials, modelling of professional situations and assessment of the educational process. Therefore, the understanding of digitalisation of teacher training in the regulatory aspect begins with defining the position of the speciality A5 "Vocational Education (by specialisations)" in higher education (Ministry of Education and Science of Ukraine, 2019), since the framework of the system of competences, specialisations and educational results is determined on the basis of this. Resolution of the Cabinet of Ministers of Ukraine No. 1021 (2024), the speciality A5 "Vocational Education (by specialisations)" has been formally defined within the updated structure of fields of knowledge and specialities.

This means that vocational education has officially become a special area for the preparation, linked not only to teaching as an educational process, but also in specific fields of professional activity. Future teachers were prepared for work at the intersection of pedagogy, vocational pedagogy, and the industry. Order of the Ministry of Education and Science of Ukraine No. 192 (2025) further specified speciality A5 through the approval of a list of specialisations used for the allocation of state and regional educational orders. Such a definition implied that the training in the speciality A5 is not uniform. It involves different professional and industrial directions – in construction and welding, electronics and electrotechnics, energy engineering and power engineering, mechanical engineering and engineering in agricultural production, transport, and digital technologies. This made it possible to consider the implementation of digital technologies and AI as a component that needed to correspond to the profile of a particular specialisation. In the technical specialisations, the focus had been on digital modelling, virtual simulators, automated systems and data analysis. In the fields linked to digital technologies, communication, design or service, priority has been given to the use of generative tools, visualisation, support for individualised learning and work with digital services. The higher education standards for the speciality A5 "Vocational Education (by specialisations)", for bachelor, master and Doctor of Philosophy were kept as the base for the formation of the competences and learning results in current and transitional educational programmes. In these standards, the digital component was presented as the capacity to use information and communication technologies to select contemporary teaching tools, organise the educational process and professional training of learners. These provisions laid the basis for further expansion of digital competence content, taking into account the AI technologies.

Digital competence has emerged as a component of professional readiness in the training of vocational education teachers. For teachers of vocational education, it was related to planning the educational process, selecting digital tools, and creating educational materials. For the teachers of specialised disciplines, it implied the ability to explain the complex professional processes with digital modelling, simulations and visualisations. For the industrial training masters, the digital competence was important in the organisation of training, demonstration of professional actions, evaluation of practical skills, and work with digital simulators. The content of this competence gradually expanded. Basic knowledge of information and communication technologies (ICT) was not enough to ensure the professional training quality. Teachers should use digital educational environments, electronic resources, distance learning platforms, simulators, analytical services, and AI tools. Thus, the role of digital technologies in education has also changed; they are used not only for the transfer of information, but also for professional situation modelling, learning tasks adaptation, independent work support and learners' outcomes analysis. However, digital competence consolidation within the professional training structure did not address the issue of AI introduction. The higher education standards were defining only the general capacity of work with ICT, digital technologies; the educational documents of the contemporary period and international recommendations have determined how educators should apply intelligent systems in educational practice. The need to expand digital competence through the inclusion of AI corresponded with the findings of Y. Bekdemir (2024), where the integration of artificial intelligence into teacher training was viewed as a condition for the renewal of the teaching profession. It was established that future teachers should be prepared not only to use individual digital services but also to work with intelligent systems that influence lesson planning, educational content creation, assessment, and interaction with learners. In this regard, the author's conclusions confirmed that digital competence requires substantive expansion through an AI component. The study results have complied with this position, further specifying it in vocational education. It was shown that the introduction of AI should be taken into account in the training of teaching staff, not only the general pedagogical functions, but also sectoral specialisation, specific nature of professional tasks, and different roles of vocational education teachers, specialised discipline educators and industrial training masters.

Recommendations from the Ministry of Education and Science of Ukraine & Ministry of Digital Transformation of Ukraine (2024) regarding the integration of

AI into the education process outline how generative tools can be used in the teaching process responsibly. AI was defined in these documents as an assistance resource in creating teaching materials, designing assignments of various complexity levels, searching and generalising information, as well as creating conditions for individualisation of learning. For example, teachers were able to form a pool of example exercises on a topic using AI, create tests and control questions, adapt the level of explanation of a specific topic for the learners, and develop a lesson plan. However, in the recommendations, it is stated that AI outputs should be checked, since AI can produce inaccurate, incomplete, or misinterpreted information. The Ministry of Education and Science guidelines on the use of AI in higher education further extended this perspective in relation to the training of future professionals (Ministry of Education and Science of Ukraine (2025). AI was also viewed as an additional resource for performing individual tasks, as well as a resource embedded into the educational, research and independent learning process. For professional training of vocational education teachers, it meant that the curricula had to cover the topics of pedagogical use of artificial intelligence, critical analysis of information generated by machines, choice of the AI technologies for solving certain educational tasks and their ethical use. In particular, future teachers should not only learn how to use AI to obtain notes, control materials, training tasks, etc., but also to check their completeness, relevance to learning objectives, scientific correctness, terminological correctness, and relevance to the specific target audience of learning. The UNESCO AI Competency Framework for Teachers (UNESCO, 2023) describes teachers' competency in AI in more detail, including aspects of technical, pedagogical, ethical and social nature. Under the technical nature, the authors understood knowledge of the principles of functioning of artificial intelligence systems, their capabilities and limitations. Under the pedagogical, there is a connection with learning objectives, the choice of methods and procedures for learning, the assessment of learning outcomes, and student support. Under the ethical, the transparency of actions, responsibility for the results, data security, plagiarism and authorship rights, academic integrity. Under the social, an understanding of the influence of AI on interaction in learning, fairness, accessibility and inclusion, the professional role of the teacher. This conceptualisation was the theoretical basis for teaching and training to view AI as one of the components of professional competency of the vocational education teachers, with particular emphasis placed on the integration of technology, pedagogical content, and ethical considerations. A comprehensive understanding of AI competence is aligned with the position of R. Daher (2025), where the integration of artificial intelligence literacy into teacher education was examined from a critical perspective. It was stressed that teacher training cannot be limited to knowledge of how intelligent systems work; educators need to comprehend the effects of these systems on the content of the curriculum, on educational interaction, on learner autonomy, and on the evaluation process. It was noted that the ability to critically assess an artificial intelligence's answers, to reveal bias, to evaluate the degree of transparency of digital tools, and to preserve pedagogical responsibility should be considered an element of AI literacy. The findings of this study were consistent with this approach in recognising the ethical and critical components of AI literacy. At the same time, they refined this concept in the context of vocational education: they proved that the critical employment of AI was not just associated with universal pedagogical threats, but also with the specifics of a particular area of knowledge, with educational and training opportunities within an industry, and with the variety of roles that educators fulfil.

By aligning national documents with international ones, it became possible to define the priorities for reforming the educational programmes of discipline A5 "Vocational Education (by specialisations)". While the state regulations of Ukraine regulate the content of the discipline by means of establishing a framework, a list of specialities, and general requirements for the expected results of learning, the recommendations of international organisations focus on the content of AI competency of the future teacher in technological, pedagogical, ethical and social dimensions. In the system of professional training of teachers of vocational education, this means a modernisation of educational components focused on digital technologies, the inclusion of materials on generative AI, the creation of practical assignments on simulating professional situations, training of skills on checking AI-generated content, and determining the ethical boundaries of its use. In this way, the theoretical and regulatory prerequisites for the progressive introduction of AI into the system of preparing future teachers of vocational education have been laid. The new version of the classification of disciplines has shown the place of the discipline A5 in the structure of higher education, the list of specialisations has clarified the sectoral orientation of training, the new standards have established digital competency as one of the components of professional development, while national and international recommendations have given this category content on responsible artificial intelligence application. The correlation of national documents with international ones allowed determining the areas for updating the educational programmes on speciality A5 "Vocational Education (on specialisations)"

Representation of digital technologies and AI in educational programmes

The analysis of the educational programmes of the discipline A5 "Vocational Education (by specialisations)"

shows the practical level of implementation of requirements of regulatory documents concerning digital competency and the use of modern technologies in the process of professional training of the teaching staff. Their content makes it possible to see how digital technologies are incorporated into professional training, how they are implemented and what aspects are considered basic and what are still undefined. Analysing the content of programmes gives the opportunity to determine how the general requirements for standards intersect with the specific features of professional education training, how digital technologies are implemented within the educational standards and where artificial intelligence is used. In addition, a comparison of Ukrainian and foreign experience makes it possible to determine how vocational teacher training is organised, to see what methods for implementing AI exist and where the education programme could improve.

Moving from regulatory documents to the analysis of the content of educational programmes allowed determining how the requirements for digital competence and the implementation of modern technologies have been implemented in the content of teacher training in the vocational education system. The content of educational programmes showed that digital technologies have been gradually introduced as an additional tool or as part of a professional specialisation, as part of the formation of the subject and professional competences of future teachers. For example, the digital component is introduced at the level of the goals of the educational programme "A5 Vocational Education (Digital Technologies)" at Lutsk National Technical University (2025). The aim was to train specialists capable not only of using digital tools, but also of teaching specialist subjects related to digital technologies. The content of this programme provides for a combination of pedagogical skills and professional knowledge to develop and design educational software, create digital educational products, and use digital technologies within the framework of educational activity. The implementation of these types of education programmes shows that digital technologies are not an addition to the training, but its content. In the Ukrainian State University of Chemical Technology (2024) educational programme "Vocational Education. Digital Technologies", such an educational programme also contains digital technologies, but digital technologies in the programme are emphasised more by its relationship with the practical component. The content of the study is implemented in the context of professional activity through the use of digital technologies to solve applied tasks, create digital products and conduct teaching in industrial production. The content of training is oriented towards combining theoretical knowledge with practical skills, in particular through elements of dual education involving engagement with real professional settings. In this approach, digital technologies function as a tool that ensures the connection between learning and professional practice. A common trend for educational programmes in Ukraine is also presented in the standard educational programme of a bachelor's degree in accordance with the requirements of speciality A5 (Educational and Research Institute of Vocational and Pedagogical Studies, Ukrainian Academy of Engineering and Pedagogy, 2021). In this programme, digital technologies appear either as a specific field of study or as a means of organising the educational process. Therefore, even if they are not a separate subject of professional preparation in the study area, they remain an inevitable part of the future teachers' professional activity. Thus, a basic level of digital training is ensured for all students of the programme, and at the same time, the possibility of additional digital specialisation. According to the results of synthesising the analysed programmes, digital technologies were presented in the training of vocational education teachers as an object of study, a means of implementation, and a component of professional activity. This allowed the laying of the foundation for further introduction of more complex digital technologies, including artificial intelligence, into educational programmes. In the content analysis of the programmes, digital technologies were most often represented by the components of the use of information and communication technologies, digital educational resources, educational software and distance learning platforms. At the same time, the direct inclusion of artificial intelligence as a content component was rather scarce. In the educational programmes considered, AI was often referred to indirectly as part of the broader concept of digital technologies or as an innovative tool for teaching, without specifying specific tools, learning outcomes, or a module on working with intelligent systems.

In the analysis of the content of educational programmes, the components of digital training were most often found in the following areas. Most often, digital tools were used to organise the educational process, create educational materials, work with electronic resources, and support vocational training. The grouping of the most frequently encountered functions made it possible to reveal the technical, methodological, organisational and resource components of the information and communication competence. Thus, knowing the place of digital technologies in educational programmes, there is a need to understand by means of which components the information and communication competence of the future vocational education teachers is trained. The digital component in the contents of educational programmes was not presented in one educational component and one discipline, but it was distributed among different disciplines and educational components. Each of them guaranteed one of the sides of professional preparation of a teacher: technical, methodological, organisational or resource.

Thus, the ICT competence is represented by a certain functionally organised system and is associated with a number of pedagogical and practice-oriented professional activities (Fig. 1)

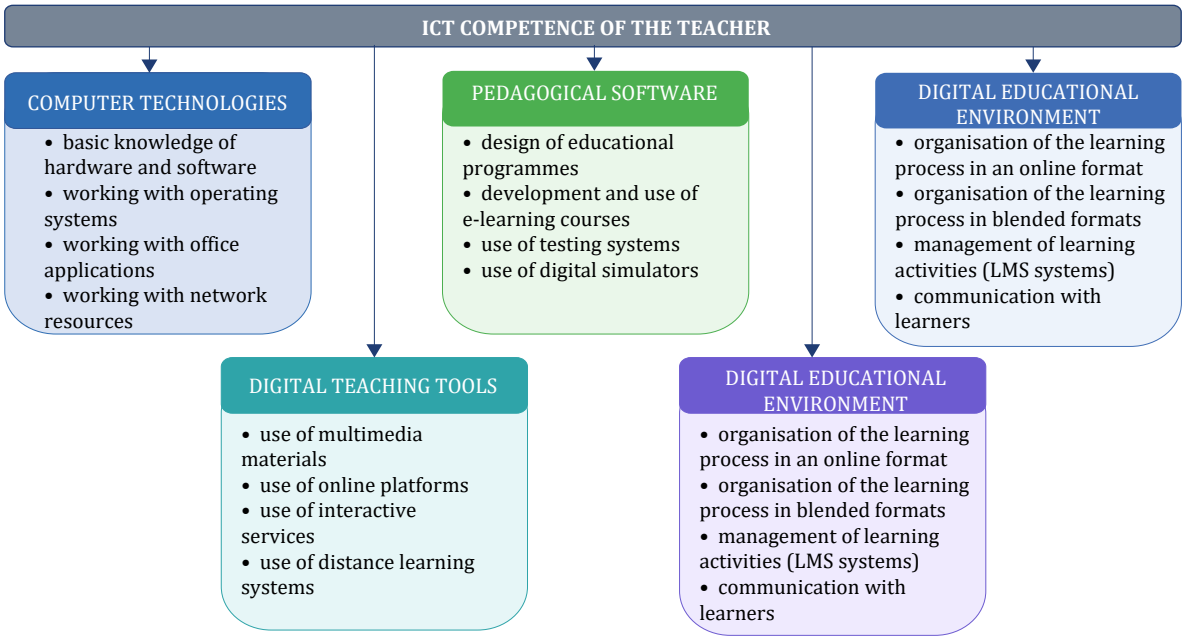

Figure 1. *Structure of ICT competence representation in educational programmes*
Source: *developed by the author based on research I. Andrusiak & M. Slyvka (2022), L. Lukianova (2022)*

The identified components demonstrated that the information and communication competence had been formed as a compound ability including technical knowledge, pedagogical skills, and organisational skills. It is formed not only by mastering some technical tools, but also implies the integration of their use in the professional activity, in full compliance with the goals and objectives of the educational process. This way of doing it gradually moved from using technology for operational tasks to using it in a more conscious, purposeful way for educational work. A similar understanding of the structure of digital competence aligns with the findings of S.R. Chohan & G. Hu (2022), who established that the effective development of digital skills is achieved not through the isolated mastery of individual tools, but through systematically organised training programmes that combine technical skills, practical application, and institutional support. It is known that digital competence is developed as a person's ability to exist in the digital medium as an integrated skill. It is very important to have access to technology and be able to use digital technology for professional tasks and challenges. The results confirmed that a structured training approach, which ensures interconnection between different components of digital activity, enhances the effectiveness of competence development. In the present study, this approach was further refined through a more detailed specification of the content of ICT competence in the training of vocational education teachers. Unlike the generalised approach, which focuses on institutional programmes for the development of digital skills, it was found that in vocational pedagogical training, such integration is implemented through the distribution of functions across educational components corresponding to different types of teaching activity. This made it possible to specify the mechanisms of competence formation and directly link them to the professional tasks of future teachers.

Practical level of competence development could be observed in the content of disciplines related to the usage of computer technology in the educational process. In these educational components, digital technologies are used as a means of educational organisation, preparing learning materials, using electronic resources, applying software tools for organising teaching activity, and assessing student learning outcomes. Within the content of such components, the students acquire the ability to choose digital resources according to educational purposes, adapt digital tools in conditions of vocational teaching, and assess the efficiency of the tool usage. In this way, this type of discipline could be considered as providing not only an introduction to technologies but also as providing tools to develop practical digital skills that relate to vocational teachers' professional activity. This is also the feature that is typical for the Ukrainian vocational teacher training programmes – ICT competence is integrated so that technology can be used as a basis for a learning organisation. However, the links with using digital tools such as artificial intelligence are still inconsistent.

These findings regarding the necessity for the functional differentiation of training are in line with those presented by R.W. Daryono *et al*. (2023). It has been established that the assessment of the competences of vocational education students should consider not just the level of acquired knowledge, but also the ability to apply it in real situations that are relevant to the professional activities that students are expected to carry out in the future. These are the applied, operational and contextual characteristics that constitute professional readiness. The present study corroborates this, showing a link between the use of AI and the real, professional functions of teachers. It became evident that for vocational teachers, educators of specialised subjects, and industrial training masters, different situations of application for the artificial intelligence tools were needed, so that the skills related to the use of intelligent technologies could not be defined as something universal. Consequently, competence in working with intelligent technologies cannot be formed as a universal skill but must correspond to the type of professional tasks, the nature of learning activities, and the methods used to assess training outcomes. The selective inclusion of artificial intelligence in training should be refined by considering that the training for various categories of teachers must be functional. It is the professional activities that define the characteristics of using digital tools, which determine different ways of using the artificial intelligence content that is part of the training.

An analysis of the content of educational programmes and professional functions shows that the directions of the use of digital technologies and AI tools will vary according to the type of professional activity. For vocational teachers, emphasis was given to design and assessment; for lecturers of specialised subjects, emphasis was on professionally oriented digital materials and the modelling of situations; and for industrial training masters, on demonstration of a technique, instruction and the use of simulators. This allowed for a functional differentiation of the domains in which the AI is applied. This type of role differentiation makes it possible to establish more specific ways of using intelligent tools for each category of teaching staff in line with its professional functions (Table 1).

Table 1. *Use of artificial intelligence in the training of different categories of vocational education teachers*

Category of teaching staff	Areas of AI use	Functional purpose
Vocational teacher	curriculum design; adaptation of educational materials; assessment of learning outcomes; support for individual learning pathways	organisation and personalisation of the learning process
Lecturer of specialised disciplines	modelling of professional situations; work with sector-specific data; creation of visualisations; preparation of technical explanations; development of case studies and simulations	provision of the content and applied components of vocational training
Industrial training master	delivery of instruction; analysis of production errors; development of action algorithms; use of virtual simulators; practice of professional operations in a safe environment	formation of practical skills and competences

Source: developed by the author based on research V. Umanets *et al*. (2024), I. Marynchenko (2025), O. Derevyanchuk *et al*. (2025)

The relationship that was identified confirms that the integration of artificial intelligence into professional training has a differentiated approach. The use of AI was determined not only by the level of digital literacy, but above all by the teacher's professional role and the type of educational tasks. In turn, this led to the question of functional specialisation in the training of pedagogical staff, and included relevant components oriented towards a practical use of intelligent technologies in certain areas of pedagogical activity. Having clarified the functional differences in the training of categories of teaching staff, it made sense to look at the situation with the training of pedagogical staff in the countries of the European Union, in which the integration of artificial intelligence into vocational training has already taken on an orderly nature. These approaches involved not only the use of individual digital tools, but also of coherent models of training for pedagogical staff in the vocational field.

For instance, within the framework of the European project AI VET (AI VET Project Consortium, 2025), training materials specifically for vocational education teachers were prepared. It followed a model of modular content organisation, with each module focused on the use of AI tools in various aspects of the training activity (development of teaching materials, organisation of the learning process, assessment, data analysis and learning adaptation according to learner needs). It also paid particular attention to the technical and pedagogical nature of the use of AI technologies, which made it possible to view AI as a tool integrated into vocational education rather than as a universal digital tool. This model of training was oriented to the use of the practical application of technology within specific industrial and educational contexts. A similar approach was adopted in the AI Pioneers (n.d.) project in the field of adult education and vocational training. In this context, AI was used as a tool for continuous professional development and training, and teachers were trained in the use of intelligent technologies. The programme covered training in the

use of intelligent systems, the creation of educational content, the use of analytics to assess outcomes, and the organisation of personalised learning pathways. This approach has made it possible to integrate AI into the professional practice of teachers as a tool to improve the quality of teaching, and in the course of AI learning to use intelligent technologies, respectively. At the national level of development, the AI experience of Estonia is particularly interesting. The introduction of AI in education has already taken on a certain systematic nature. Within the framework of the AI Leap (Education Estonia, 2025) initiative, AI technologies were made available to both students and teachers, and the teacher training process was supported through training and methodological materials. A distinctive feature of this model is the combination of technological accessibility with the promotion of responsible attitudes towards the use of AI, including ethical considerations, critical thinking, and learner autonomy. All this allowed the integration of AI tools into the educational process at all levels, including vocational education.

Greece started teacher training on the use of AI in the educational process in 2025-2026, which included the relevant modules in the continuing professional development systems (Reuters, 2025). The content of this training covered lesson planning with the use of intelligent tools, the application of AI in research activities, and the organisation of personalised learning. This approach focused on the gradual introduction of technologies into the teachers' professional activities through acquiring practical skills and methodological competences. The discussed approaches can be compared in that the integration of AI into the system of vocational education within the European educational space was carried out on the basis of the educational programmes, projects and public policy. In all of the considered models, the role of artificial intelligence as a part of teachers' professional competence, which is developed during specialised training and practical preparation, as well as through methodological support, is acknowledged. At the same time, Ukrainian educational programmes already provide a developed digital foundation, but the introduction of AI still requires clarification of its contents, results of learning and ways of implementation. This determined the necessity to identify the opportunities and obstacles for AI implementation in the system of vocational teacher training. Comparative analysis has shown that, while in European practice the integration of AI in the educational process is carried out through the creation of training modules, scenarios for the practical use of intelligent technologies and providing the teachers with methodological support. In contrast, digital training in Ukrainian educational programmes preserves a more general approach to digital training and the AI-related components are included only partially in the teachers' professional activities.

Opportunities and barriers to AI integration in teacher training

The implementation of AI in the system of vocational teacher training was accompanied simultaneously by the expansion of didactic possibilities and the appearance of obstacles associated with regulatory, methodological, staffing and technological support. These changes occurred in the framework of the existing digital foundation of educational programmes. While it created prerequisites for the integration of AI, it did not ensure its systematic introduction. This determined the necessity of considering the introduction of intelligent technologies as not only a technical upgrade but a comprehensive transformation of the content, organisation and results of the vocational teacher training. The use of AI has led to the expansion of the range of tools for the organisation of the learning process in vocational teacher training. The main directions of such expansion included the personalisation of learning, which was associated with the possibility to adapt the content, learning pace and complexity based on the individual characteristics of learners. The result has been a more differentiated approach to training future teachers, enabling the level of preparation, professional needs and interests of future teachers to be taken into account in the course design.

Another key element in this process has been the automated production of learning materials. AI made it possible to generate texts, tests, training cases and scenarios of professional situations for the training process, which facilitated and accelerated the preparation of lessons, broadened the range of teaching materials and ensured greater flexibility in their use. Simulations and virtual educational environments have helped to create conditions for training in a digital environment, so in vocational teacher training, it has become possible to model industrial situations, train students in performing sequences of actions, and train them in professional skills in a digital environment, without having to be involved in real production processes. Another direction has been the analysis of educational data, which made it possible to track the student's progress, analyse results and adjust the educational process. Use of data analysis made it possible to increase the validity of pedagogical decisions and to achieve a more objective analysis of learning results (Boiko *et al*., 2024). As a result of the integration of artificial intelligence, there are now reasons to reconsider the content of the educational programme in speciality A5. One of the directions has been the creation of educational blocks for more specific training for the use of AI in vocational education. This content includes familiarity with intelligent systems, the possibilities of their use in professional education, and their limitations. Another area has been the inclusion of AI content in the curricula of other educational disciplines.

When considering digital technology courses, teaching methodology for vocational education, professional

skills, and student performance assessment, there is a clear understanding that AI is an available tool for various sectors of pedagogical practice. This approach makes it possible to introduce intelligent technologies without radically changing the structure of the educational programme. A separate focus has been placed on developing learning outcomes related to the responsible use of AI. The need to develop such outcomes aligns with the position of A.C. Saglam (2025), where the integration of artificial intelligence in education is linked primarily to preparing teachers for informed pedagogical use of intelligent tools. The study emphasised that the effectiveness of AI depended not on the mere fact of its use, but on the teacher's need to be able to identify the technology they should be using to teach students, select the appropriate one based on the objectives of their teaching activity and monitor the impact of the technology on the educational interaction. AI competence is seen as a necessary part of professional training for vocational teachers, not as a separate technology. The current study extends this concept with a specific list of learning outcomes for speciality A5. Responsible implementation of AI in training future vocational education teachers involves, first of all, assessing the quality of the generated content, ethical work with data, the relevance of the chosen tools to the professional task and verifying the educational value of the developed digital products.

This involves training in assessing the quality and reliability of generated content, observing ethics and taking security into account, as well as the use of AI, in line with educational objectives. The findings didactic possibilities correspond to the results of A. Suparyati *et al*. (2023), where they identify the main role of AI in vocational education as providing learning adaptability, automating some pedagogical processes, and developing opportunities for practice-oriented training. The authors state that with the help of intelligent technologies, it is possible to personalise the content of learning tasks, improve the procedures for assessing students, provide students with access to digital resources and create prerequisites for modelling professional situations. All this testifies to the relevance of considering AI not just as a supporting tool for vocational education, but as a technology for the didactic transformation of vocational education. In this study, the above theses are further developed with regard to vocational teacher training. Whereas the authors primarily present AI as a resource for the broader development of vocational education, this study clarifies the specific didactic functions it can perform in the training of future teachers: the creation of learning materials, the design of scenarios of industrial situations, the support of simulations, learning analytics, and the development of the ability to use intelligent tools in a pedagogically appropriate manner.

The use of artificial intelligence has facilitated a shift from basic use of digital tools to their critical selection and application. The training of future teachers has involved the development of the ability to select appropriate AI services depending on educational objectives, evaluate their effectiveness, and adapt them to specific learning contexts. An important aspect was the formation of skills for quality and reliability verification of generated AI content, namely the quality of the provided information, its compliance with learning goals, awareness of the limitations of automated systems and many other aspects. Such knowledge and skills become relevant for the professional activity of teachers in digital environments. The digital competence is also prepared for work in digitalised professional environments. Future teachers must be prepared to use AI as a tool for organising teaching, interacting with learners and professional development. Alongside these opportunities, the integration of AI has been accompanied by a number of constraints emerging at different levels of the vocational teacher education system (Honcharuk *et al*., 2024). The transition from the general use of digital tools to a critical selection of AI services corresponds to the results of T. Rachbauer *et al*. (2025), where they highlight digital literacy and artificial intelligence literacy as related but not identical components of teacher preparation. The research suggests that digital competence involves the skills and abilities that are necessary to function in a digital environment, whereas AI literacy relates to understanding the operation of systems that utilise intelligence, assessing AI-generated outputs, recognising the potential risks associated with such technologies, and considering the pedagogical implications. This has clarified the content of digital competence, which, in the current circumstances of the active introduction of AI, cannot be limited solely by technical skills for the use of digital tools. The findings of the present research correspond to this differentiation, but at the same time specify it with reference to the process of preparing teachers to work in technical and vocational education. It is concluded that AI literacy should not only imply the ability to understand intelligent technologies, but also to correlate them with professional tasks and their content, specialisations of the sector, production contexts, and the educational content of practical training of learners.

The identified duality of opportunities and limitations also confirms the results obtained by A. Zary & N. Zary (2025), in which the role of artificial intelligence in technical and vocational education is considered from the combination of the demonstrated positive and the revealed negative. It has been established that AI makes it possible to organise adaptive training, carry out automation of assessment, create a simulation-based environment, and prepare students for performing professional tasks; however, the use of such tools depends on the readiness of the implementation, organisational aspects, infrastructure, teacher

competence, as well as the availability of appropriate mechanisms. In turn, the results of the present research correspond to these results, in which the potential of AI is not considered separately from the conditions of its implementation. At the same time, these results are complemented by the specifics that are presented only in the study of training of teaching staff in technical and vocational education. The authors describe the issues and challenges in the broader sense for technical and vocational education, while current research specifies them through the lens of educational programmes, as well as the digital competence of the future teacher and the differences in the functions of teachers of vocational education, the educators of specialised disciplines, and industrial training masters.

Unevenness of the preconditions for AI implementation confirms the results of the research of W. Flores & A. Chiappe (2025), according to which the introduction of AI in education should be considered as a combination of various preconditions and digital competence of the teacher. It has been established that the readiness of teachers to use artificial intelligence is not limited by digital skills and the ability to work with tools, but is determined by the possibility of using their teaching value and the ability to adjust them to teaching content and the presence of support conditions from the educational organisation. This made it possible to view digital competence as a prerequisite for implementation, rather than merely as an outcome of learning. The findings of the present study are consistent with this conclusion in recognising staffing and methodological factors as key to AI integration. At the same time, they further specify the structure of constraints in vocational education: it has been shown that teacher readiness depends on regulatory clarity, methodological provision, access to technology, and the alignment of AI with specific professional tasks. This allows barriers to be described more broadly as an interrelated system rather than a collection of separate difficulties. The conditions for the systematic implementation of AI have proved uneven, which has necessitated a synthesis of the main barriers (Table 2).

Table 2. *Barriers to the implementation of artificial intelligence in vocational teacher education*

Group of barriers	Nature of the barrier	Manifestations in vocational teacher training
Regulatory	lack of clear requirements for the use of AI; transitional nature of the classification of specialities; insufficient detail regarding ethical and legal aspects	limited integration of AI into standards and educational programmes; unclear learning outcomes
Methodological	lack of models for AI integration; insufficient methodological materials; formalised use of AI	use of AI without clear links to professional competences; limited methodological support
Staff-related	uneven levels of teachers' digital training; insufficient readiness to use AI; need for further professional development	fragmented implementation of technologies; dependence on individual teacher experience
Technological	unequal access to infrastructure; restricted access to services; issues of security and data protection	limited use of AI in teaching; risks to academic integrity

Source: *developed by the author based on research S. Nykyporets (2024)*

These grouped barriers correspond to the results of a systematic review conducted by Y. Aljemely (2024), which reveals that teacher readiness to apply artificial intelligence is impeded by a complex of technical, organisational, ethical, and professional-methodical factors. According to its results, the training process of teachers includes not only the availability of artificial intelligence tools, but also a well-organised programme of training of teachers, a set of scenarios of their application, institutional support of innovations, as well as a clarification of issues such as confidentiality, academic integrity and proper use of data. The researchers noted the key role of long-term professional support of teachers, since short-term training in artificial intelligence is insufficient to form a stable readiness to use intelligent means. The findings of this study coincide with this position in emphasising the multilevel structure of the barriers. At the same time, they refine them within the context of vocational education: it has been shown that methodological and staff readiness must correspond to the profile of specialisation, the functions of vocational teachers, educators of specialised disciplines, and industrial training masters, as well as the requirements of learners' practical preparation. The systematisation of the barriers reflects their interconnectedness and mutual influence. Regulatory uncertainty limits methodological development, staff-related difficulties reduce the effectiveness of available technologies, and technological constraints hinder the implementation of even those approaches that have already been developed. This indicates the need for a comprehensive approach to AI implementation that takes into account all levels of the educational system. The integration of artificial intelligence into vocational teacher education thus combines significant potential for renewing the learning process with a range of systemic constraints. The didactic opportunities associated with the personalisation of learning, the automation

of content creation, and the use of simulations and analytics have created preconditions for improving the quality of training. At the same time, the integration of AI has required the revision of educational programme content and the development of digital competence at a new level. The ratio of advantages and barriers to the use of artificial intelligence confirms the results of S. Ahmed *et al*. (2022), which showed that the motivation of teachers to apply these technologies is high, given the transparency of the advantages of its use for learning organisation, materials preparation, result evaluation, and students' support. At the same time, in practice, the development of AI is limited by low preparation of teachers, lack of methodical support, technical difficulties and ambiguity of ethical principles. Accordingly, the positive attitude towards the use of AI did not guarantee its effective use without the appropriate organisational and professional conditions. The findings of the present study are consistent with this conclusion in that the didactic potential of AI is considered alongside a system of constraints. At the same time, the results further specify the nature of these constraints in vocational teacher education: it has been shown that barriers arise not only at the level of individual teacher readiness, but also at the level of educational programmes, regulatory clarity, access to infrastructure, and the alignment of AI with specific professional functions of teachers. The existing barriers demonstrate that the implementation of AI cannot be limited to isolated initiatives or localised changes. This requires harmonisation of the regulatory framework, development of methodological solutions, preparation of teaching staff, and provision of appropriate technological conditions. Under these conditions, the effectiveness of AI integration depends on the capacity of the education system to combine the potential of intelligent technologies with the requirements of vocational teacher education.

Conclusions

It has been established that the theoretical and normative foundations for the preparation of the pedagogical staff of vocational education laid the foundation for the digital transformation, and did not specify in detail the use of artificial intelligence in the training process. The accreditation of the speciality A5 "Vocational Education (by specialisations)" confirms the autonomy and interdisciplinarity of this speciality, the national recommendations on the definition of requirements for digital competences and their international interpretation extend the understanding of digital professionalism by including the ethical and social aspects of interaction with intelligent technology. An analysis of educational programmes revealed that the use of digital technologies was represented as a component of specialisation content, while in most cases, the use of AI was indirect. In comparison with the European practices, it was found that, in the latter case, the introduction of AI was more systematic, and was realised as specialised modules, project activities or as state-level programmes.

The generalisations of findings have shown the following: The introduction of artificial intelligence into vocational teacher education has the potential to open up new didactic perspectives. These included personalising the learning process, automating the creation of educational content, using simulations and virtual learning environments, and employing learning analytics to evaluate the quality of learning outcomes. At the same time, these opportunities were associated with the need to update curricula, introduce dedicated components, define new learning outcomes, and develop digital competence oriented towards the critical and responsible use of AI. There are, however, a number of barriers to the systematic introduction of artificial intelligence. Regulatory barriers, such as an absence of clear requirements for the use of AI as part of standards or in educational programmes. Methodological barriers are connected to underdeveloped models of how to introduce AI into vocational teacher education. Staff-related barriers resulting from the uneven level of digital readiness of lecturers and their insufficient readiness to use intelligent technologies. Technological barriers, including problems with access to digital infrastructure and the use of specialised services, and the issue of data security. The barriers identified are interrelated, and it is necessary to adopt an integrated approach to overcoming them.

The findings confirmed that the effective integration of artificial intelligence into vocational teacher education is possible, but only if the regulatory requirements, methodological support, lecturer training and technical infrastructure are developed and properly implemented. This highlights the need for further updates to educational programmes, which are necessary for the incorporation of AI within the professional competence of vocational teachers. Further research needs to be done in the context of the increasing sample size of analysed educational programmes and legal acts, which need to include a variety of educational programmes in terms of different specialisations and organisations. It is also necessary to conduct research in the field of empirical analysis of the efficiency of the introduction of artificial intelligence in vocational teacher education while taking into account the rapid development of technology and changes in educational practice.

Acknowledgements

None.

Funding

None.

Conflict of Interest

None.

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Сучасні підходи до впровадження цифрових технологій (штучного інтелекту) у системі професійної підготовки педагогічних кадрів закладів професійної освіти

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Анотація. Метою дослідження було з'ясування умов, потенціалу та обмежень використання технологій штучного інтелекту у підготовці педагогічних працівників для закладів професійної освіти шляхом аналізу нормативних документів і змісту освітніх програм. Методологія дослідження ґрунтувалася на поєднанні нормативно-документального аналізу, контент-аналізу освітніх програм і порівняльного аналізу освітніх практик. У результаті дослідження було встановлено, що теоретико-нормативна база підготовки педагогічних кадрів професійної освіти сформувала передумови для впровадження цифрових технологій, однак не забезпечила достатньої конкретизації застосування штучного інтелекту. Виявлено, що освітні програми інтегрували цифрові технології як зміст спеціалізації, інструмент навчання та компонент професійної діяльності, проте використання штучного інтелекту залишалося фрагментарним і не набуло статусу системного елементу підготовки. Встановлено, що інформаційно-комунікаційна компетентність формувалася як багаторівнева структура, яка забезпечувала технічну, методичну та організаційну готовність педагога, але не повною мірою охоплювала роботу з інтелектуальними системами. Порівняння з європейськими освітніми практиками показало, що інтеграція штучного інтелекту в професійну освіту здійснювалася через спеціалізовані модулі, проєктні ініціативи та державні програми, що забезпечувало її системний характер. Визначено, що використання штучного інтелекту розширило дидактичні можливості професійної підготовки за рахунок персоналізації навчання, автоматизації створення освітнього контенту, застосування симуляцій і освітньої аналітики. Одночасно встановлено наявність нормативних, методичних, кадрових і технологічних бар'єрів, які стримували повноцінну інтеграцію інтелектуальних технологій. Практична значимість дослідження полягає в тому, що його результати можуть бути використані для оновлення освітніх програм, розроблення освітніх компонентів із використання штучного інтелекту, уточнення результатів навчання щодо цифрової компетентності та підготовки методичних матеріалів для педагогів професійного навчання, викладачів спеціальних дисциплін і майстрів виробничого навчання

Ключові слова: освітні програми; цифрова компетентність; нормативна база; компетентність; персоналізація