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Theoretical and methodological approaches to modernisation of IT specialist training in the context of sustainable development and digitalisation of education

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■ **Abstract.** The study aimed to analyse the effectiveness of educational programmes in the fields of F2 Software Engineering, F3 Computer Science, and 126 Information Systems and Technologies, and to identify ways to improve them based on the needs of the industry. The research methodology included questionnaires, quantitative analysis, comparative analysis of educational programmes, and expert evaluation of teaching materials. During the study, conducted in September 2024, the study determined that educational programmes for training specialists in computer science, software engineering, and information systems need to be updated following labour market requirements. An analysis of teaching materials revealed that most educational programmes do not update the technologies and tools used in the professional sphere, nor do they consider the development of digital skills and principles of sustainable development. Moodle was the most popular learning platform, used by 40% of respondents. According to teachers' assessments, students' digital literacy is mostly at an average level (56.6%). Only 31.6% of respondents noted a high level, which indicated a need for professional competence development. The student survey revealed that a blended form of educational organisation dominates (over 60% support) in combination with a high level of digital autonomy among students (79% study materials independently). The analysis of training revealed that although there are isolated attempts to integrate innovative technologies, in particular artificial intelligence, their implementation is insufficient for the full development of specialists. There is a need to improve teaching methods through the integration of online courses and project activities. The results can be used by teachers and administrators of higher education institutions to improve training methods, to update educational programmes in line with the requirements of the modern labour market

■ **Keywords:** digital technologies; technological changes; information security; critical thinking; self-learning

■ Introduction

Training specialists in information technology (IT) has become relevant in the context of the transition to a sustainable development model and the active introduction of digital technologies in all spheres of public life, particularly in education. Sustainable development requires the formation of professional competence that combines knowledge in the field of information technology with awareness of environmental, social and economic challenges. The transformation of the education system involves rethinking educational approaches, the content of educational programmes, teaching methods, and the development of students' critical thinking, self-learning, interdisciplinary interaction and innovative activities. There is a growing demand

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for specialists who are not only capable of developing IT solutions, but also address the principles of ethical use of technology, digital security, energy efficiency and environmental impact. There is a problem of adapting the IT training system to the new conditions of digitalisation and the challenges of sustainable development, which requires updating the conceptual foundations of professional training, introducing innovative educational practices, strengthening the interdisciplinary nature of learning and developing digital culture among students. The need for such an update is determined not only by rapid technological changes, but also by the need to ensure a balance between technical competence, social responsibility and environmental awareness among future IT professionals.

Several studies addressed various aspects of IT specialist training in the context of digitalisation and transformation of the educational space. In particular, Y. Tryus & I.V. Herasymenko (2021) emphasised the introduction of elements of dual education into the training process for future IT specialists. The study proposed effective models, methods, and means of training that combine academic education with practical experience in enterprises. The results show an improvement in the quality of student training thanks to the systematic integration of the educational process with real production conditions. B. Zulauf & N. Knipprath (2020) investigated the specifics of training IT specialists in university computer centres. The study emphasised the need for practice-oriented training, which includes the implementation of real projects, work with infrastructure tasks and participation in the technical support of IT systems of institutions. This format contributes to the formation of professional skills and readiness for practical activities. O. Yezhova (2024) revealed the possibilities of using digital technologies in the professional training of specialists in the field of technology and design. The study showed that the use of digital tools increases students' interest in learning, promotes the development of creativity, interdisciplinary thinking, and independence in the learning process.

Theoretical and methodological approaches to developing the educational potential of students in higher education institutions (HEIs) were proposed by V. Leleka *et al.* (2023). The study emphasised personality-oriented education, self-realisation of students, and the development of their professional autonomy, which are key factors in the high-quality training of IT specialists. M.A. Alzahrani (2025) addressed the significance of assistive technologies in teaching students with disabilities in an inclusive education environment. Although the study does not exclusively concentrate on IT specialists, it emphasises the significance of adapting digital solutions to the needs of different categories of learners, which is also relevant for the training of future IT specialists. L.I. Bilousova *et al.* (2024) presented their experience of implementing interdisciplinary projects in the training of future IT specialists. The study demonstrated that cross-sector integration promotes the development of systematic thinking, communication skills, and the ability to solve complex problems in the IT field. The researchers emphasise the importance of teamwork in such projects, as it develops cooperation skills in a real professional environment. In addition, the integration of several disciplines improves mastery of the practical context of the IT industry.

I. Hevko *et al.* (2020) emphasised the development of practical skills in modelling and printing three-dimensional objects during professional training. The use of 3D technologies not only improved mastery of modern tools among students but also contributed to the development of spatial thinking, design skills and engineering competence. Such technologies ensure interactivity and clarity of the learning process, which increases student motivation. The above-mentioned studies mostly focused on individual aspects of IT specialist training, namely dual education, digital technologies, interdisciplinarity or technical skills, but did not sufficiently cover a comprehensive model of professional training in the context of sustainable development. The study aimed to analyse educational programmes in Ukrainian higher education institutions. The objectives of the study were to analyse curricula and teaching materials to identify benefits and issues; to determine the relevance of teaching materials to the modern requirements of the IT industry and the needs of the labour market based on a survey of study participants; to develop recommendations for improving educational programmes, incorporating the requirements of IT companies and trends in the IT sector.

Materials and Methods

The study analysed the curricula and educational programmes at bachelor's level at three leading higher education institutions in Ukraine: the Interregional Academy of Personnel Management (IAPM), the National Technical University "Kharkiv Polytechnic Institute" (NTU KhPI) and Vinnytsia National Technical University (VNTU). These universities were selected due to their representativeness in the field of IT education, different forms of ownership (public and private institutions), and the availability of accredited educational programmes. The analysis covered the curricula and methodological materials of bachelor's degree programmes in the specialities F2 Software Engineering, F3 Computer Science and 126 Information Systems and Technologies. Identification of the advantages and disadvantages of training and the level of integration of sustainable development principles into the content of training were emphasised.

The study also used methodological materials, in particular: textbooks (Dovgalets & Masliy, 2009; Butenko & Syry, 2020) to analyse traditional approaches to teaching basic IT disciplines in Ukrainian higher education

institutions; online courses on the Udacity and Coursera platforms to compare the content of modern international training. The course "CS50: Introduction to Computer Science" on edX was used as an example of a comprehensive general introduction to computer science with an emphasis on practical skills. The presentations [RE-183] Machine learning theory and algorithms (n.d.) were selected as a representative example of methodological support for Ukrainian technical programmes.

The study, conducted in September 2024, included a survey of 240 IT students (80 from each university). The sample of students included students aged 17 to 22 (132 males and 108 females) studying technical subjects. The criteria for inclusion in the study were: studying IT disciplines at the specified higher education institutions and voluntary consent to participate in the survey. The criteria for exclusion were the absence of informed consent or withdrawal from the survey process. Sixty IT teachers were also surveyed, 20 from each university. A separate questionnaire consisting of closed questions was used for each category of respondents (students and teachers). Responses were recorded in a multiple-choice format, which facilitated quantitative analysis. Responses were scaled using nominal and ordinal scales, depending on the nature of each question. The survey was conducted in person using paper questionnaires, which respondents filled out directly in the classrooms. After the questionnaires were collected, the data were processed and analysed using quantitative statistical methods. Questionnaire for students of technical specialities:

1. Which learning format do you consider to be the most effective? (Face-to-face/Distance learning/Blended learning)
2. Are you familiar with the concept of "sustainable development" in the context of IT? (Yes, very familiar/Heard of it, but know little about it/No)
3. Which digital platforms do you use most often during studies? (Moodle/Google Classroom/Zoom or Teams/Other)
4. What proportion of the learning material is studied independently using online resources? (More than 50%/20-50%/Less than 20%/I do not use online resources)
5. Do you have sufficient practical training for your future profession? (Yes/Partially/No)
6. What skills should be prioritised in IT education, in your opinion? (Teamwork/Critical thinking/Working with big data/Other)
7. How would you rate the level of digitalisation at your educational institution? (High/Medium/Low)
8. Would you like to participate in international educational IT projects? (Yes/Maybe/No)

The questionnaire for IT teachers consisted of the following questions:

1. Is the concept of sustainable development included in your educational programmes? (Yes/Partially/No)
2. Which digital educational platforms do you use most often in teaching? (Moodle/Google Classroom/Microsoft Teams/Other)
3. How would you rate the level of digital literacy among students? (High/Medium/Low)
4. What forms of educational process organisation do you practise most often? (Face-to-face/Distance learning/Blended learning)
5. Have you taken any advanced training courses in digital pedagogy? (Yes, regularly/Yes, once/No)
6. What topics should be covered more extensively in IT specialist training? (Ethical aspects of technology/Green IT/Cybersecurity/Other)
7. What difficulties do you most often encounter when introducing innovations in teaching? (Insufficient technical support/Resistance to change/Lack of time/Other).

The collected data were statistically processed using descriptive statistics methods, which determined the average values, frequencies, and trends in respondents' assessments. The analysis of the obtained data identified key aspects that influence the effectiveness of learning and teaching technical disciplines in conditions of constant change. The results obtained contributed to the formulation of recommendations based on the requirements of IT companies. The study was conducted following the American Sociological Association's Code of Ethics (1997) on ethical principles for research involving human subjects. All participants provided written consent to voluntarily participate in the study.

Results

Analysis of curricula and teaching materials

The training of specialists in the field of information technology largely depends on the content of educational programmes, the structure of curricula, the relevance of teaching materials, and the alignment of the educational process with the current challenges of digital transformation and sustainable development. An analysis of the curricula of three bachelor's programmes: F2 "Software Engineering" (n.d.) at the Interregional Academy of Personnel Management, Computer science. Modelling, design and computer graphics (n.d.) at the National Technical University "Kharkiv Polytechnic Institute" (F3 Computer Science) and Educational programme "Intelligent Information Systems" (Bachelor's degree) (n.d.) at Vinnytsia National Technical University (126 Information Systems and Technologies) – revealed both common features and differences in the priorities of training students.

The F2 "Software Engineering" (n.d.) educational programme has an applied focus, emphasising software development, testing, and quality assurance. Its content is geared towards developing the practical skills necessary for graduates to quickly integrate into the professional environment. Automated testing tools, software code construction principles, and working with

command development systems are given special attention. The programme demonstrates a clear connection between applied disciplines, ensuring the integrity of the training. The educational programme Computer science. Modelling, design and computer graphics (n.d.) is characterised by a fundamental orientation and a deep theoretical foundation. Its structure includes mathematical logic, algorithms, data structures, information theory, software engineering, and artificial intelligence. The sequential study of disciplines ensures gradual mastery of the basic and specialised aspects of computer science. The programme promotes the development of analytical thinking, which is critical for research and development and the creation of innovative IT products. Educational programme "Intelligent Information Systems" (Bachelor's degree) (n.d.) focuses on IT infrastructure management, information systems design and administration, and the implementation of digital services. Emphasis is placed on IT project management that meets market requirements in the context of the development of e-government, financial technologies, and the digital economy. Students receive IT project management as a key focus, meeting market demands in the context of e-government, financial technology, and the digital economy. Students learn about corporate systems, cybersecurity, user interaction, and technical support.

A substantial component of IT specialist training is the use of methodological materials that ensure high-quality assimilation of the educational material. For example, the manual by S.M. Dovgalets & R.V. Masliy (2009) serves as the main source for studying algorithms and programming languages such as C++ and Python. It is notable for its logical structure and contains practical tasks for independent study. In turn, the textbook by T.A. Butenko & V.M. Syry (2020) covers a wide range of topics: from databases and telecommunications to the basics of cybersecurity and the organisation of IT systems. Additional resources include interactive online courses, including CS50: Introduction to Computer Science from Harvard University, which provides basic training in computer science, and the Machine Learning specialisation from Stanford University (Coursera), which introduces students to modern machine learning algorithms and their practical application. Authored teaching materials are also widely used, including the presentations [RE-183] Machine learning theory and algorithms (n.d.).

The organisation of the educational process in IT specialities is characterised by flexibility and practical orientation. The main forms include lectures, laboratory and practical classes, seminars, project-based learning, participation in hackathons, internships and workshops. A significant part of the educational process aims to solve real-life cases, develop software products, and defend coursework and theses of an applied nature. Pedagogical support for learning is based on the principles of constructivism, active independent acquisition of knowledge through practice, and the principles of andragogy, which incorporate the needs and motivation of adult learners. Modern methodological approaches are used: problem-oriented learning, project method, case method, blended learning, flipped classroom, and elements of gamification. Digital platforms (GitHub, Microsoft Teams) are actively used to provide asynchronous learning, teamwork, and individual educational trajectories. This approach contributes not only to the formation of professional knowledge and skills but also to the development of critical thinking, responsibility, time management, and effective communication.

The educational programmes of specialities F2 Software Engineering, F3 Computer Science, and 126 Information Systems and Technologies have both strengths and certain limitations that affect the quality of training of specialists in the field of IT. The Computer Science and Intelligent Systems programme provides a thorough study of algorithms and data structures, which are fundamental to the development of high-performance systems and machine learning systems. Practical training is prioritised: laboratory assignments are conducted using the Python and Java programming languages, as well as modern artificial intelligence libraries such as TensorFlow and PyTorch, which meet the requirements of employers. Students can work on projects involving the development of intelligent agents and robotic systems, gaining practical experience in solving real-world problems. The academic programme is complemented by the integration of online courses, such as Machine Learning, which provides access to relevant case studies and the latest tools. At the same time, there are certain shortcomings, in particular the use of outdated methodological manuals (Dovgalets & Masliy, 2009; Butenko & Syry, 2020), which do not cover modern AI frameworks and cloud services. There are also no separate training modules on cybersecurity and building DevOps pipelines using Docker, Kubernetes, and CI/CD systems. In addition, cooperation with IT companies on organising internships and implementing practical case studies in the local market is limited.

The F2 "Software Engineering" (n.d.) programme specialising in Software Engineering focuses on a comprehensive study of the software development life cycle, from planning and coding to testing and support. Learning modern collaboration tools is a substantial part of the programme: version control systems (Git), agile methodologies (Agile, Scrum), and continuous integration tools (Jenkins, GitLab CI). Students complete project work on the development of web and mobile applications using React, Node.js, and REST API, which simulates typical commercial tasks. However, the programme lacks a practical component in the field of containerisation and orchestration, in particular, working with Docker and Kubernetes. In addition, there are no in-depth courses on cloud platforms such as Amazon Web Services, Azure or Google Cloud, which limits

students' preparation for deploying production environments. The block on machine learning or working with big data is also insufficiently represented, which reduces the interdisciplinary potential of the programme. In turn, the Information Systems and Technologies programme provides students with knowledge of comprehensive database processing (SQL, NoSQL), network technologies and server administration, which meets the market demand for specialists in the field of DBMS and infrastructure engineering. The programme also includes modules on IT governance, digital ethics and sustainable IT principles, which promote mastery of environmentally responsible design and provide knowledge on GDPR compliance. The ability to choose a specialisation (cybersecurity, data analytics or IoT) through elective disciplines makes the programme flexible and adaptable to the individual needs of students. An additional advantage is the use of the CS50 course, which provides a systematic awareness of the basic principles of computer science. At the same time, some teaching materials, such as the presentation [RE-183] Machine learning theory and algorithms (n.d.), are only of theoretical value and lack interactive components such as simulations or hackathons. There is also the use of outdated technologies, such as Hadoop and Spark, without adaptation to modern cloud data centres. Limited interaction with the business environment remains a significant problem: students lack access to open data and real-world cases from IT companies to address practice-oriented projects.

In general, educational programmes for training IT specialists in Ukrainian higher education institutions demonstrate compliance with international educational standards, in particular the recommendations of the ACM & IEEE Computer Society (2013) on training bachelors in computer science, as well as the standards of the European Committee for Standardisation (2014) standards, which define professional competencies in the field of ICT (information and communication technologies) within the European Higher Education Area. This applies primarily to content, the use of digital resources, and the development of key professional and interdisciplinary competencies. However, there is still a need for further modernisation of educational programmes, updating of methodological materials, and more active integration of the principles of sustainable development and the development of digital culture. Such an update will contribute to more effective training of specialists capable of responding to the challenges of the digital economy and actively participating in the sustainable development of society.

Evaluating the effectiveness of methodological and theoretical approaches in training IT specialists

The quality of training for future IT specialists largely depends on the systematic evaluation of the methodological and theoretical approaches used. In the context of rapid technological change and growing demands on the qualifications of IT specialists, universities must not only update the content of their programmes, but also constantly review the effectiveness of their teaching methods. The quality of the educational process directly affects the ability of graduates to quickly adapt to the needs of the labour market, implement innovations and work in a highly competitive environment.

To identify the modern state of use of methodological and theoretical approaches in the training of IT specialists, as well as to assess the level of integration of modern educational practices in university courses, a questionnaire was developed for teachers of IT disciplines. The main aspects of the survey provided a comprehensive overview of the implementation of modern methodological approaches in higher IT education, as well as identifying areas for improvement (Table 1).

Table 1. *Results of a survey of IT teachers*

Question	Answer options	IAPM	NTU KhPI	VNTU	Total
Is the concept of sustainable development taken into account in your educational programmes?	Yes	8	10	7	25
	Partially	9	6	10	25
	No	3	4	3	10
What digital tools do you use most often in teaching?	Moodle	7	9	8	24
	Google Classroom	6	4	5	15
	Microsoft Teams	3	5	4	12
	Other	4	2	3	9
How would you rate the level of digital literacy among students?	High	5	8	6	19
	Average	13	10	11	34
	Low	2	2	3	7
What forms of training do you practise most often?	Face-to-face	4	5	6	15
	Remotely	6	5	4	15
	Mixed	10	10	10	30
Have you taken any advanced training courses in digital pedagogy?	Yes, regularly	5	6	4	15
	Yes, once	9	8	10	27
	No	6	6	6	18

Table 1. Continued

Question	Answer options	IAPM	NTU KhPI	VNTU	Total
What topics should be covered more extensively in IT specialist training?	Ethical aspects of technology	6	4	5	15
	Green IT	5	7	6	18
	Cybersecurity	7	7	8	22
	Other	2	2	1	5
What difficulties do you most often encounter when introducing innovations in teaching?	Insufficient technical support	6	5	5	16
	Resistance to change	3	4	3	10
	Lack of time	7	8	8	23
	Other	4	3	4	11

Source: *compiled by the author*

An analysis of the results of a survey of IT teachers at three universities revealed quantitative and qualitative characteristics of the modern state of integration of digital tools and sustainable development principles into the educational process. Regarding the inclusion of the concept of sustainable development in educational programmes, 41.7% of respondents indicated that it is fully included, another 25% (41.7%) indicated that it is partially included, while 16.6% indicated that it is completely absent. Moodle was found to be the most widely used tool in teaching digital disciplines, with 40% of respondents using it. Google Classroom (25%) and Microsoft Teams (20%) are used slightly less frequently. Other tools were mentioned in 9 cases (15%). These results indicate a certain preference for locally installed learning management systems over cloud services. Regarding the assessment of students' digital literacy, most teachers (56.6%) consider it average, 31.6% consider it high, and 11.8% consider it low. This distribution shows that, according to teachers' observations, a significant proportion of students have only basic digital skills, which can be a barrier to the effective acquisition of the latest IT knowledge. In terms of teaching methods, blended learning prevails, practised by 30 teachers (50%). Fifteen teachers (25%) use both face-to-face and distance learning methods. This demonstrates the growing popularity of a combined approach, which correlates with global trends in the digital transformation of education. Regarding professional development in digital pedagogy, 45% of respondents had taken relevant courses once, 25% had attended regularly, and 30% had never participated. Among the topics that, according to teachers, require more attention in the training of IT specialists, the most frequently mentioned were cybersecurity (36.6%), green IT (30%) and ethical aspects of technology (25%). This choice demonstrates the relevance of an interdisciplinary approach to training future IT specialists. Regarding the readiness of graduates for the challenges of the digital economy, the majority of respondents (36 people, or 60%) chose the option "partially". Only 23.3% of people consider the training to be sufficient, while 16.7% do not. This indicates a gap between the educational process and the demands of the labour market. Teachers cited lack of time (38.3%), insufficient technical support (26.6%) and resistance to change (16.6%) as the most common difficulties in implementing innovations. These barriers need to be addressed in the management decisions of higher education institutions.

The survey results indicate certain dynamics in the renewal of the educational process in the field of IT, revealing critical points that require further improvement. In the context of digital transformation, it is necessary not only to modernise the content of disciplines, but also to ensure sustained support for teachers, expansion of digital infrastructure and increased practical orientation of courses. The next stage of the study was a survey of students in technical specialities, which provided an insight into the educational process from the perspective of student experience (Table 2).

Table 2. *Results of a survey of students studying technical subjects*

Question	Answer options	IAPM	NTU KhPI	VNTU	Total
Learning format is considered to be the most effective	Face-to-face	17	15	19	51
	Remote	14	12	11	37
	Mixed	49	53	50	152
Familiarity with the concept of "sustainable development" in IT	Yes, well aware	19	18	16	53
	Aware of the concept, but have little knowledge about it	40	42	38	120
	No	21	22	24	67
Most commonly used digital platforms	Moodle	28	31	26	85
	Google Classroom	22	20	23	65
	Microsoft Teams	20	19	20	59
	Other	10	10	11	31

Table 2. Continued

Question	Answer options	IAPM	NTU KhPI	VNTU	Total
Share of independently learned material	More than 50%	26	28	25	79
	20-50%	36	37	38	111
	Less than 20%	14	11	12	37
	Online resources are not used	4	4	5	13
Sufficiency of practical training	Yes	21	23	25	69
	Partially	43	40	38	121
	No	16	17	17	50
Required skills for further development	Collaboration	27	24	26	77
	Critical thinking	22	23	20	65
	Big data handling	25	26	27	78
	Other	6	7	7	20
Level of digitalisation of higher education institutions	High	20	22	24	66
	Average	43	41	40	124
	Low	17	17	16	50
Desire to participate in international IT projects	Yes	50	53	54	157
	Possibly	24	22	20	66
	No	6	5	6	17

Source: *compiled by the author*

A survey of students revealed key features of their perception of the educational process and their level of preparation for professional activity in the IT industry. First of all, the results showed a predominance of interest in a blended learning format: it was supported by more than 60% of respondents. The traditional face-to-face format was supported by about a fifth of respondents, while fully distance learning proved to be the least popular, with less than 16%. This indicates that students are keen on combining the flexibility of online learning with the effectiveness of live communication. In terms of awareness of the concept of "sustainable development" in the IT field, only 22% of respondents indicated a mastery of the topic. Half of the students are only superficially familiar with it, while 28% have never heard of this concept. This indicates a need for the targeted introduction of relevant disciplines into technical education programmes. When it comes to the use of educational digital platforms, students most often turn to Moodle, followed by Google Classroom and Teams. In particular, these three platforms together account for over 85% of responses, confirming their dominance in the educational process. The share of alternative platforms was insignificant, which indicates a limited range of digital tools in everyday learning. Most students actively use online resources for self-study: over 79% of respondents study 20 to 50% or more of the educational material independently. Only a small proportion of students (approximately 5%) do not engage in independent work with digital resources, indicating a general trend towards digital autonomy among students. As for practical training, only slightly more than a quarter of respondents consider it sufficient. Instead, the majority (71%) assess their level of practical skills as partial or insufficient. This highlights the need for more active implementation of practice-oriented courses, internships, and project activities. The identification of the most sought-after skills yielded an interesting result: approximately one-third of students chose working with big data, almost as many chose teamwork, and one-quarter chose critical thinking. This demonstrates awareness of the importance of both technical and soft skills in professional growth. Most respondents rated the level of digitalisation in educational institutions as average, slightly less than a third rated it as high, and one in five rated it as low. Such variability in ratings may indicate both differences between institutions and uneven implementation of digital practices within a single institution. Lastly, 65% of respondents expressed high motivation to participate in international IT projects, with more than a quarter considering such an opportunity. Only a small number of students rejected such initiatives, demonstrating the potential for active international integration.

During the survey of all participants in the study, several aspects were identified that indicate non-compliance with substantial principles of the modern educational process in technical specialities. One of these principles is the principle of practical orientation of education, which is critical for training specialists in the field of IT. Most students rate the level of practical training as insufficient, which indicates that the educational process does not sufficiently address the development of practical skills. This is also confirmed by the high level of independent learning using online resources, which highlights the lack of practical tasks and projects in the academic programme. The lack of a practical component in education may result in graduates not having the necessary skills to work in real labour market conditions. Another principle that has not been sufficiently reflected in the educational process is the personalisation of learning. According to the survey results, students believe that the blended learning format has become the most effective, but most of them do not

receive enough individual attention during their studies, which is confirmed by the lack of adequate practical training. This also indicates that the educational process needs to be adapted to different types of students and their needs, particularly those who are interested in specific technologies or methods, such as working with big data or teamwork.

According to the survey results, most students actively use online resources for self-study, which expands the knowledge of students outside the scope of the academic programme. At the same time, this self-study process is a substantial tool for the development of critical thinking. The use of online courses, videos, articles, and practical learning tools not only improves mastery of new technologies among students but also helps them evaluate them from different perspectives, which contributes to the development of analytical skills and further research of the material. A substantial component of self-learning is that it promotes the development of critical thinking in students, especially in the context of technological innovation. When students learn new technologies independently, they often encounter problems that require a creative approach to solving tasks. Therefore, students can develop skills for solving non-standard problems by evaluating different options and justifying their choices. Thus, self-study not only provides the necessary knowledge but also actively influences the formation of critical thinking, which is one of the key competencies of a future IT specialist.

Recommendations for improving educational programmes, incorporating the requirements of IT companies and trends in the development of the technology sector

Improved educational programmes for IT specialisations are necessary in light of the rapid development of digital technologies and growing employer demands for specialists in this field. To improve the learning process and eliminate identified shortcomings, it is necessary to comprehensively modernise the content of education, methodological approaches and forms of learning organisation, focusing on the real needs of the labour market and the experience of leading IT companies. In particular, it is necessary to integrate educational programmes with the practical activities of IT companies. This can be achieved through the introduction of dual education, where part of the training takes place directly at the companies' premises, using their technical environment, tools and practices. It is also advisable to create joint educational trajectories with the participation of practising specialists who will be involved in developing courses, giving lectures, conducting workshops, and mentoring student projects.

Leaders of IT companies such as EPAM System and SoftServe note that specialists who have not only technical knowledge but also critical thinking skills, teamwork skills, the ability to quickly adapt to new technologies, mastery of the principles of software architecture, DevOps approaches, systems thinking, and Agile frameworks are most valued. They also emphasise the need for knowledge of cybersecurity, cloud technologies (Amazon Web Services, Azure), artificial intelligence, machine learning, and working with big data. For educational programmes to meet these expectations, the content of academic disciplines needs to be reviewed. For example, it is advisable to include courses on modern programming languages, as well as a more in-depth study of frameworks. It is advisable to integrate classic relational systems, namely MySQL and PostgreSQL, into the educational process, as they provide a high level of data consistency, support for complex transactions, and the SQL standard. Modern NoSQL solutions, such as MongoDB, should be used for their flexible document storage scheme, which facilitates scaling, and Cassandra, which is notable for its high fault tolerance and linear scaling when processing large amounts of data. In addition, cybersecurity modules should be strengthened, particularly in the areas of penetration testing, cryptography, and secure coding, as these areas provide practical skills for identifying vulnerabilities, ensuring data confidentiality, and developing secure software products, which are critical in the context of growing threats to information security.

Theoretical and methodological approaches should be modernised separately. Traditional lectures should be replaced by interactive formats: live case discussions, simulations of real projects, the use of peer learning methods, and the active introduction of problem-oriented and project-based learning. Methodologically, textbooks should be updated, for example, by replacing outdated materials with modern interactive platforms such as Codecademy, LeetCode, and HackerRank, where students can practise practical tasks with automatic code verification. It is worth following the example of CS50, Stanford CS229, Google Career Certificates, Microsoft Learn, and IBM SkillsBuild courses, which combine short theoretical blocks with practical tasks, certification, and career growth recommendations. Some ideas that can be borrowed from modern IT courses include the use of mentoring, adaptive learning with automatic task difficulty selection, integration of real cases from open source projects, and involvement of applicants in competitions such as Google Summer of Code. Another positive practice is individual development trajectories, where students can choose their specialisation: backend, frontend, data science, DevOps, cybersecurity, game development, etc. The feasibility of methodological and theoretical approaches needs to be assessed systematically. In particular, surveys of students can be used to assess the quality of teaching, the level of material assimilation, and the relevance of the subject matter. For example, if most students indicate that the tasks are theoretical and do not correspond to modern tools (e.g., they do not use Git, Docker, or CI/CD

systems), this indicates a need to change the methodology. Another substantial indicator is the results of independent testing, student participation in hackathons, competitions, open-source projects, and start-ups. Assessment can also be conducted through external audits by IT companies: experts can analyse curricula, attend coursework defences and internships, and review projects. For instance, EPAM Systems can provide its mentors to evaluate students' teamwork in a real project. Constant monitoring and open dialogue between education and business can ensure contribution of methodological and theoretical approaches to the formation of true specialists in the modern IT industry.

The learning process can also be improved through regular analysis of learning outcomes using digital tools (LMS analytics, performance tracking, reflective journals) and feedback from students and employers. Involving IT companies in certification commissions, participating in joint research projects, and introducing start-up incubators at universities contribute to the formation of a professional environment during the learning process.

Among the key recommendations for improving educational programmes, the following can be highlighted integration of new technologies and trends regular updating of course content to reflect trends in IT, such as generative artificial intelligence (GPT, LLM), Web3, blockchain, quantum computing; updating teaching materials; creating interactive textbooks with multimedia elements; integrating learning platforms into the overall teaching system; refocusing on practice: 70% of learning should be practice-oriented, including project creation, stage-based learning, and working with real technical tasks; career guidance and mentoring creating educational tracks that can be used by students to choose a specialisation and orient themselves in real professions; interdisciplinarity and soft skills; introduction of courses in project management, communication, entrepreneurship, and digital ethics.

Thus, the modernisation of educational programmes, incorporating the requirements of IT companies, must be systematic, dynamic and based on partnership between higher education institutions and industry representatives. Only under such conditions is it possible to train competitive specialists who are not only able to work effectively in an IT environment, but also to be a driving force for innovation in the digital economy.

Discussion

The results of this study showed that updating the content of IT specialist training programmes is necessary to ensure compliance with digitalisation and sustainable development trends. This is consistent with the findings of O. Popelo *et al.* (2024), emphasising that the digitalisation of universities must be integrated into educational processes, providing not only technical knowledge but also the development of competencies related to the digital economy. Similar conclusions were also made by P. Vinh (2021), emphasising that global trends in the digital transformation of education require the adaptation of IT education programmes to the real needs of the labour market. In addition, personalised training programmes contribute to improving the level of training of IT specialists, as they incorporate the individual needs of students. This is partly consistent with the findings of F. Fraile *et al.* (2023), proposing a methodological model of personalised learning to support professional development in Industry 5.0, based on an analysis of students' competencies and needs. Another substantial aspect is the development and accreditation of educational programmes for IT specialists. The results of this study demonstrate that the use of dynamic software contributes to the development of students' analytical thinking, which is substantial in the training of IT specialists. A similar point of view is supported by V. Yunchyk *et al.* (2021), arguing that cognitive modelling of the learning process has a positive effect on the formation of professional skills of IT specialists. The results of the study confirmed that the use of a new approach to curriculum design can effectively adapt the content of education to the requirements of the labour market. This is consistent with the findings of T. Kovaliuk *et al*. (2020), noting that ontological models can be used to create structured educational programmes that meet the real needs of the IT industry and promote greater flexibility in curricula. In addition, a substantial aspect of updating the training of IT specialists is the development of soft skills, in particular communication, teamwork and critical thinking skills. This correlates with the conclusions of B. Zulauf & N. Knipprath (2020), noting that modern IT specialists must have not only technical competencies but also well-developed interpersonal skills. I. Shishenko *et al.* (2020) also noted the same idea, highlighting that the use of interactive teaching methods can be used by students to develop both technical and social skills.

The results of this study showed that the use of new learning models in the professional training of IT specialists contributes to the development of analytical thinking, the optimisation of learning processes, and the improvement of the effectiveness of independent learning. This is consistent with the findings of S. Jacobs & S. Jaschke (2023), arguing that integrating different models into the learning process can accelerate adaptation of future IT specialists to the changing demands of the labour market and improve efficiency of complex programming task solution. The authors also emphasised that artificial intelligence models can act as mentors, promoting personalised learning and expanding students' opportunities for independent mastery of complex material. The study also found that the use of a cloud environment in database training has become an effective tool for training IT specialists, as it provides practice with real technologies and develops practical skills. This is consistent with the findings of

O. Korotun *et al.* (2020), demonstrating that cloud-based learning models improve students' big data skills and increase their competitiveness in the labour market. This is also confirmed by the research of O. Kopishynska *et al.* (2020), noting that the integration of cloud technologies can be used by students to access advanced information systems and promotes closer interaction between educational institutions and the IT industry. The results of this study indicate the significant role of additional online courses in the training of IT specialists, especially in the context of developing flexible educational models. This is consistent with the research of T. Sobchenko & O. Zhelizniak (2023), who noted that this contributes to the formation of professional competence by increasing the accessibility of knowledge and providing personalised learning. Similar conclusions were also made by S. Sharov *et al.* (2021) in an analysis of the effectiveness of massive open online courses in programming education, and they concluded that such courses are a powerful tool for expanding the professional opportunities of future IT specialists. The structured organisation of such courses affects student success. This is consistent with the findings of E. Kaila & K. Lemström (2023), demonstrating that well-organised courses with a defined schedule promote improved learning, while flexible courses without a fixed schedule can lead to lower student engagement.

The results of the study also demonstrated that the continuous improvement of information technologies in the educational process of future IT specialists contributes to the formation of professional skills. This is consistent with the findings of O. Karupu *et al.* (2021), confirming that the use of digital technologies in mathematical disciplines improves mastery of algorithms, technical literacy, and contributes to the development of logical thinking among students. In addition, interactive teaching methods can also be an effective means of increasing student motivation to study IT disciplines. This correlates with the findings of M. Sade *et al.* (2021), confirming that after completing programming courses based on game mechanics, students demonstrated better results in mastering the material. A similar study by U. Stoltenberg & G. Michelsen (2023) noted that digital technologies and interactive methods can contribute to the development of competencies necessary for sustainable development by combining technical and ethical aspects of learning. In the context of sustainable development, the results of this study confirm that the digital transformation of higher education is a key factor in ensuring sustainable management of the educational process. This is consistent with the findings of E. Abad-Segura *et al.* (2020), demonstrating that digitalisation contributes to improving the effectiveness of learning, expanding access to educational resources and reducing environmental impact by reducing the use of paper materials. The results of this study also demonstrated that integrating sustainable development principles into higher education can help train IT specialists who prioritise not only technological progress but also environmental and social responsibility. This is consistent with the study by D.A. Charkova & E. Somova (2023), conducted among IT students in Bulgaria. In particular, 67.3% of respondents believe that university education should promote the development of social and environmental skills, and a significant proportion of students are willing to refuse jobs related to fossil fuels or choose lower salaries in favour of environmental principles.

The study revealed several issues in the professional training of IT specialists, including insufficient practical training and a gap between theoretical knowledge and labour market requirements. This is consistent with the findings of O. Sysoiev (2022), identifying a similar situation in the economic sphere, where educational programmes do not always meet the real needs of professional activity. Similar results were obtained by G. Tomer & S.K. Mishra (2023), determining that many IT specialist training programmes do not include enough case studies related to real work situations, which makes it difficult for graduates to find employment. Nevertheless, the results of this study confirm that updating the training of IT specialists in the context of the digitalisation of education and sustainable development should be based on a personalised approach, the integration of the latest technologies, close cooperation with the IT industry, and the use of innovative teaching methods.

Conclusions

An analysis of curricula and teaching materials for training IT specialists showed that the educational programmes F2 Software Engineering, F3 Computer Science and 126 Information Systems and Technologies are sufficiently structured and practically oriented. The programmes combine fundamental knowledge with applied competencies relevant to the digital economy and Industry 4.0. Teaching materials, including printed manuals, author presentations and online courses, meet the modern challenges of digitalisation. Interactive forms of learning are substantial, promoting the development of analytical thinking and teamwork skills necessary for successful professional fulfilment in the IT field.

The study, which covered both IT teachers at three higher education institutions in Ukraine and students, identified modern trends, problems and potential in the organisation of the educational process in the field of information technology. An analysis of the teachers' questionnaires showed that although the concept of sustainable development is partially integrated into the curricula, the full inclusion of this topic still needs to be strengthened. The results of a survey of 60 IT teachers indicate a low level of integration of the concept of sustainable development into the curricula. The results of the survey of IT teachers showed that 56.6% consider

the level of student preparation to be average for the challenges of the digital economy, and 31.6% consider it to be high, while 11.8% assess it as low, indicating a need to update the content of education. Despite the popularity of the blended format (50%) and the active use of Moodle (40%), only 25% of teachers regularly took advanced training courses in digital pedagogy, which may hinder the effective integration of modern digital solutions into the educational process. Teachers and IT company managers noted the relevance of developing not only technical skills, but also soft skills: critical thinking, teamwork, and adaptability to technological changes. The blended learning format, supported by over 60% of respondents, along with a high level of digital autonomy (79% of students master a significant part of the material independently) and active use of three main educational platforms (85% of responses cover Moodle, Google Classroom and Teams), demonstrates the adaptability of students to the modern integrated learning environment. At the same time, only 22% of respondents are deeply familiar with the concept of "sustainable development", and 71% indicate an insufficient level of practical training, which highlights the need to strengthen the applied component of education and include relevant thematic courses in educational programmes.

Inclusion of topics such as cybersecurity, DevOps, cloud technologies, big data, artificial intelligence, as well as modern programming languages and frameworks in the curriculum, was emphasised. Methodological approaches need to be modernised: instead of traditional lectures, simulations, case studies, peer learning, project-based and problem-oriented learning should be used. This will not only improve the assimilation of material but also develop critical thinking and the ability to solve complex problems independently. The limitations of the study are its focus on a sample of only three universities and the lack of a detailed qualitative analysis of motivational factors. The prospects for the study lie in further analysis of the effectiveness of the educational innovations implemented and the development of dual IT education models in collaboration with leading companies in the industry.

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Conflict of Interest

None.

References

[1] [RE-183] Machine learning theory and algorithms. (n.d.). Retrieved from https://my.kpi.ua/syllabus/183.

[2] Abad-Segura, E., González-Zamar, M.-D., Infante-Moro, J.C., & Ruipérez García, G. (2020). Sustainable management of digital transformation in higher education: Global research trends. *Sustainability*, 12(5), article number 2107. doi: 10.3390/su12052107.

[3] ACM & IEEE Computer Society. (2013). *Computer science curricula 2013: Curriculum guidelines for undergraduate degree programs in computer science*. New York: ACM. doi: 10.1145/2534860

[4] Alzahrani, M.A. (2025). The importance of assistive technology for students with disabilities in the comprehensive education schools in the KSA. *Creative Education*, 16(4), 437-447. doi: 10.4236/ce.2025.164028.

[5] American Sociological Association's Code of Ethics. (1997). Retrieved from https://www.asanet.org/wp-content/uploads/savvy/images/asa/docs/pdf/CodeofEthics.pdf.

[6] Bilousova, L.I., Gryzun, L.E., & Pikalova, V.V. (2024). Experience of interdisciplinary projects implementation in the training of pre-serviced IT-specialists. *Journal of Physics: Conference Series*, 2871(1), article number 012019. doi: 10.1088/1742-6596/2871/1/012019.

[7] Butenko, T.A., & Syry, V.M. (2020). *Information systems and technologies*. Kharkiv: Kharkiv State University of Biotechnology.

[8] Charkova, D.A., & Somova, E. (2023). The role of sustainable development in the academic curriculum and prospective employment: A survey of information technology students in Bulgaria. *International Journal of Sustainability in Higher Education*, 24(3), 1629-1647. doi: 10.1108/IJSHE-09-2022-0309.

[9] Computer science. Modelling, design and computer graphics. (n.d.). Retrieved from https://vstup.kpi.kharkov.ua/edprogram/komp-iuterni-nauky-modeliuvannia-proektuvannia-ta-komp-iuterna-grafika-bakalavr/.

[10] Dovgalets, S.M., & Masliy, R.V. (2009). *Algorithmic languages and programming. Part 1. Fundamentals of computer science and computer technology*. Vinnytsia: Vinnytsia National Technical University.

[11] Educational programme "Intelligent Information Systems" (Bachelor's degree). (n.d.). Retrieved from https://web.archive.org/web/20220226184633/https://vntu.edu.ua/uk/information-for-enrollee/osvitnya-programa-intelektualni-informaciyni-sistemi-bakalavr-1329.html.

[12] European Committee for Standardisation. (2014). *European e-competence framework 3.0 (CEN workshop agreement 16234-1:2014)*. Brussels: CEN.

[13] F2 "Software Engineering". (n.d.). Retrieved from https://maup.com.ua/ua/navchannya-u-maup/napryami-navchannya1/121-inzheneriya-program.html.

[14] Fraile, F., Psarommatis, F., Alarcón, F., & Joan, J. (2023). A methodological framework for designing personalised training programs to support personnel upskilling in Industry 5.0. *Computers*, 12(11), article number 224. doi: 10.3390/computers12110224.
[15] Hevko, I., Potapchuk, O., Sitkar, T., Lutsyk, I., & Koliasa, P. (2020). Formation of practical skills modeling and printing of three-dimensional objects in the process of professional training of IT specialists. *E3S Web of Conferences*, 166, article number 10016. doi: 10.1051/e3sconf/202016610016.
[16] Jacobs, S., & Jaschke, S. (2023). Large language models in the vocational training of IT specialists. In *INFOS 2023 – computer science education between current relevance and timelessness* (pp. 187-196). Bonn: Gesellschaft für Informatik. doi: 10.18420/infos2023-017.
[17] Kaila, E., & Lemström, K. (2023). To schedule or not to schedule: The effects of course structure on programming MOOC performance. *Informatics in Education*, 22(4), 635-650. doi: 10.15388/infedu.2023.27.
[18] Karupu, O., Oleshko, T., & Pakhnenko, V. (2021). Modeling future aviation and IT specialists' professional skills development on mathematical practical training with application of information technologies. In *Proceedings of the 3rd international conference on advanced trends in information theory* (pp. 215-220). Kyiv: IEEE. doi: 10.1109/Atit54053.2021.9678904.
[19] Kopishynska, O., Utkin, Y., Sliusar, I., Slyusar, V., Protas, N., & Barabolia, O. (2020). Professional-oriented training of specialists under implementation of cloud computing information systems in cooperation between universities and IT companies. In *Proceedings of the 14th international multi-conference on society, cybernetics and informatics (IMSCI 2020)* (pp. 17-22). Winter Garden: International Institute of Informatics and Systemics.
[20] Korotun, O., Vakaliuk, T., & Soloviev, V. (2020). Model of using cloud-based environment in training databases of future IT specialists. *CTE Workshop Proceedings*, 7, 281-292. doi: 10.55056/cte.360.
[21] Kovaliuk, T., Kobets, N., Pasichnyk, V., & Kunanets, N. (2020). Ontological approach to the development and accreditation of the educational programs for the training of IT specialists of Ukraine. In *Proceedings of the 15th IEEE international scientific and technical conference on computer sciences and information technologies* (pp. 281-286). Zbarazh: IEEE. doi: 10.1109/CSIT49958.2020.9321967.
[22] Leleka, V., Khrolenko, M., Kushnir, A., Protsenko, I., & Petriv, A. (2023). Theoretical and methodological approaches to the educational potential of students in higher education institutions. *Amazonia Investiga*, 12(71), 162-174. doi: 10.34069/AI/2023.71.11.14.
[23] Popelo, O., Kholiavko, N., Safonov, Y., Shaposhnykov, K., Babukh, I., & Yamniuk, B. (2024). Global trends of universities digitalization under the sustainable development concept. *Management Theory and Studies for Rural Business and Infrastructure Development*, 46(4), 473-481. doi: 10.15544/mts.2024.44.
[24] Sade, M., Suviste, R., & Luik, P. (2021). Measuring the post-impact of programming MOOCs: Development and validation of an instrument. *Education Sciences*, 11(12), article number 811. doi: 10.3390/educsci11120811.
[25] Sharov, S., Kolmakova, V., Sharova, T., & Pavlenko, A. (2021). Analysis of MOOC on programming for IT specialist training. *TEM Journal*, 10(4), 1884-1894. doi: 10.18421/TEM104-52.
[26] Shishenko, I., Shamonia, V., Loboda, V., Punko, V., Khvorostina, Y., & Voitenko, A. (2020). Studying dynamic mathematics software in the professional training of teachers of computer science, mathematics, and IT specialists. In *2020 43rd international convention on information, communication and electronic technology (MIPRO)* (pp. 598-602). Opatija: IEEE. doi: 10.23919/MIPRO48935.2020.9245387.
[27] Sobchenko, T., & Zhelizniak, O. (2023). Educational potential of mass open online courses (MOOC) in the formation of specialists. *Scientific Journal of Khortytsia National Academy*, 2(9), 86-97. doi: 10.51706/2707-3076-2023-9-10.
[28] Stoltenberg, U., & Michelsen, G. (2023). Theoretical reflections on education for sustainable development and digital technologies. In L. Keller, G. Michelsen, M. Dür, S. Bachri & M. Zint (Eds.), *Digitalization, new media, and education for sustainable development* (pp. 1-13). London: IGI Global. doi: 10.4018/978-1-7998-5033-5.ch001.
[29] Sysoiev, O. (2022). Professional training of specialists in the economic sphere: Gaps in the research field. *Continuing Professional Education: Theory and Practice*, 73(4), 7-26. doi: 10.28925/1609-8595.2022.4.1.
[30] Tomer, G., & Mishra, S.K. (2023). Work and career-related features of technology: A grounded theory study of software professionals. *Information and Software Technology*, 164, article number 107301. doi: 10.1016/j.infsof.2023.107301.
[31] Tryus, Y., & Herasymenko, I.V. (2021). Approaches, models, methods and means of training of future IT-specialists with the use of elements of dual education. *Journal of Physics Conference Series*, 1840, article number 012034. doi: 10.1088/1742-6596/1840/1/012034.
[32] Vinh, P. (2021). Digital transformation at universities: Global trends and Vietnam's chances. In *Proceedings of the international conference on emerging challenges: Business transformation and circular economy* (pp.73-80). Paris: Atlantis Press. doi: 10.2991/aebmr.k.211119.008.

[33] Yezhova, O. (2024). Professional training of future specialists in the field of technology and design using digital technologies. *Journal of Vasyl Stefanyk Precarpathian National University*, 11(1), 20-24. doi: 10.15330/jpnu.11.1.20-24.

[34] Yunchyk, V., Fedonuyk, A., Khomyak, M., & Yatsyuk, S. (2021). Cognitive modeling of the learning process of training IT specialists. In *MoMLeT+DS 2021: 3rd international workshop on modern machine learning technologies and data science*. Lviv-Shatsk: CEUR Workshop Proceedings.

[35] Zulauf, B., & Knipprath, N. (2020). Training of IT specialists in university computer centre. In *13th annual international conference of education, research and innovation* (pp. 6166-6170). Valencia: IATED. doi: 10.21125/iceri.2020.1328.

Теоретичні та методичні підходи до оновлення підготовки ІТ-фахівців в умовах сталого розвитку та цифровізації освіти

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■ **Анотація.** Метою дослідження було проаналізувати ефективність освітніх програм спеціальностей F2 Інженерія програмного забезпечення, F3 Комп'ютерні науки й 126 Інформаційні системи та технології та визначити шляхи їх удосконалення відповідно до вимог даної індустрії. Методологія дослідження включала анкетування, кількісний аналіз, порівняльний аналіз освітніх програм і експертну оцінку методичних матеріалів. У ході дослідження, проведеного впродовж вересня 2024 року, було виявлено, що освітні програми підготовки фахівців з комп'ютерних наук, інженерії програмного забезпечення та інформаційних систем потребують оновлення відповідно до вимог ринку праці. У результаті аналізу методичних матеріалів з'ясовано, що більшість освітніх програм не актуалізують технології та інструменти професійної сфери, а також не враховують розвиток цифрових умінь та принципів сталого розвитку. Найпопулярнішою платформою для навчання став Moodle, який використовували 40 % опитаних. Цифрова грамотність студентів, за оцінками викладачів, здебільшого середнього рівня (56,6 %). Високий рівень відзначили лише 31,6 % респондентів, що вказало на потребу в розвитку професійної компетентності. Щодо опитування студентів, то виявлено, що домінує саме змішана форма організації освітнього процесу (понад 60 % підтримки) у поєднанні з високою цифровою автономією студентів (79 % самостійного опрацювання матеріалів). Аналіз підготовки виявив, що хоча є окремі спроби інтегрувати інноваційні технології, зокрема штучний інтелект, його впровадження є недостатнім для повного розвитку фахівців. Виявлено потребу в удосконаленні методичних підходів до викладання, через інтеграцію онлайн-курсів і проектної діяльності. Отримані результати можуть бути використані викладачами, адміністраціями закладів вищої освіти для удосконалення методик підготовки фахівців, зокрема для оновлення освітніх програм відповідно до вимог сучасного ринку праці

■ **Ключові слова:** цифрові технології; технологічні зміни; захист інформації; критичне мислення; самонавчання