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CHAPTER 5

INTEGRATION OF ARTIFICIAL INTELLIGENCE TECHNOLOGIES INTO THE DIGITAL TRANSFORMATION OF PROFESSIONAL HIGHER EDUCATION IN TECHNICAL FIELDS

ABSTRACT

This chapter explores current trends in the integration of artificial intelligence technologies into the professional training of students in technical higher education institutions. The theoretical section highlights models of digital transformation, the structure of digital competences, the role of AI in adapting educational programs, as well as strategic initiatives implemented at Lviv Polytechnic National University under the leadership of rector N. Shakhovska.

Special attention is given to an empirical study based on a survey of students and instructors in technical fields. The findings identify the most anticipated benefits and barriers to AI adoption in the educational process and reveal correlations between selected advantages and the respondents' level of digital readiness. A series of visualizations is presented, including a digital competence pyramid, network graphs of stakeholder interaction, and a map of multiple associations between AI-driven educational outcomes. The results underscore the need for a systemic approach to fostering AI literacy in technical universities, the importance of digital pedagogical support for instructors, and the development of an ethical culture in the use of intelligent tools in professional education.

KEYWORDS

Artificial intelligence in education, technical higher education, digital transformation, AI literacy, digital competences, educational technologies, professional training, ethical use of AI, instructors' digital readiness, learning innovation.

In the 21st century, professional higher education faces the imperative of transformation under the influence of digital technologies, particularly artificial intelligence (AI). Technical universities, such as Lviv Polytechnic National University, are expected not only to adapt to new conditions but also to become flagships of innovative change. Today, the mission of technical education extends beyond the transfer of specialized knowledge to include the development of digital competences aligned with the demands of a dynamic labor market and contemporary digital reality.

AI functions not only as a subject of study but also as a powerful tool for transforming the educational process. Intelligent systems are already being applied to analyze educational data, personalize learning, create simulations and digital twins, automate knowledge assessment, and support students through virtual tutors and chatbots. At the same time, the implementation of such technologies requires updated teaching methodologies, ethical responsibility, and equitable access to digital solutions for all participants in the educational ecosystem. The theoretical underpinnings of AI in mathematics and education are well articulated in the frameworks reflecting current advances [1–3], emphasizing the importance of descriptive models and system categorizations.

This topic is particularly relevant in the context of the strategic development of Lviv Polytechnic National University, led by Rector Prof. Nataliia Shakhovska, Doctor of Technical Sciences and a leading expert in intelligent information technologies. The university consistently advances a policy of educational digital transformation and the expansion of digital competences among both instructors and students.

The purpose of this study is to provide a theoretical framework and empirical exploration of the integration of artificial intelligence technologies into the educational process of a technical higher education institution. Special emphasis is placed on the analysis of digital and AI-related competences, the expected benefits and challenges of implementation, and the interconnections between key components of digital transformation – as illustrated by the case of Lviv Polytechnic National University.

The object of the study is the process of developing digital and AI competences in the professional higher education system of technical profile.

The subject of the study includes the methods, models, and tools for implementing AI technologies in the educational process of a technical university, as well as the attitudes of key stakeholders toward their use.

Research objectives:

– to analyze the current state of AI implementation in professional education within technical universities;

– to identify the levels of digital and ai-related competences developed among students in technical fields;

– to investigate the expected benefits and challenges associated with integrating ai into the educational process;

– to develop a visual model illustrating the interconnections between key components of digital transformation;

– to propose a structural model for integrating AI into the system of professional higher education in technical institutions.

The methodological framework of the study includes an analysis of scientific literature and strategic documents, a comparative review of educational practices, as well as a quantitative empirical study based on surveys conducted among students and instructors in technical fields. The obtained results are presented through graphical visualizations – including pyramidal models of digital competence, network diagrams, and histograms – which help interpret the structure of perceived benefits and barriers to AI integration in education.

Structurally, the chapter comprises six thematic blocks, which the chapter combines analytical depth with practical orientation, illustrating the opportunities and prospects for expanding digital competences in modern professional higher education.

Most existing research focuses either on general overviews of IT/AI in higher education or on applications within specific disciplines (e.g., language learning or medical training). In contrast, this study presents a systematic analysis of AI implementation specifically within a technical university, taking into account internal educational policies and practices at Lviv Polytechnic National University.

The proposed original three-level model of digital and AI competences (literacy – professional use – research level) offers a framework for structuring the preparation of technical students for real-world participation in the digital economy.

An associative visualization method is applied to reveal the connections between selected perceived benefits of AI, a technique rarely used in pedagogical studies. This approach allows not only for tracking frequency of responses but also for exploring the cognitive context, identifying which advantages are interconnected in respondents' perceptions.

The study reflects real initiatives implemented at Lviv Polytechnic National University: the digital transformation policy led by Rector Nataliia Shakhovska, cooperation with the IT industry, participation in Jean Monnet and BUP projects, and the development of digital infrastructure. This gives the research a practical dimension and offers a reference model for other technical universities in Ukraine.

The chapter also includes the original survey instrument, which may be reused by other institutions to assess their readiness for AI integration. Additionally, the proposed infographics and network-based models can serve as tools for educational management and strategic planning.

5.1 THEORETICAL FOUNDATIONS FOR THE IMPLEMENTATION OF ARTIFICIAL INTELLIGENCE IN VOCATIONAL EDUCATION

5.1.1 EVOLUTION OF AIED PARADIGMS (ARTIFICIAL INTELLIGENCE IN EDUCATION)

The idea of applying artificial intelligence in education has a long history, dating back to the 1970s and 1980s when the first concepts of Intelligent Tutoring Systems (ITS) were developed. These systems were based on the assumption that a computer could model individual student needs and adapt educational materials accordingly.

The main theoretical approaches in this paradigm include:

– the intelligent tutoring paradigm, where AI acts as a mentor: it monitors progress, detects knowledge gaps, and adjusts the learning trajectory;

– the collaborative learning coordination paradigm, which emerged later and focuses on supporting student interactions, task distribution, and enhanced group learning through AI mechanisms [4].

Contemporary AI tools go beyond these early concepts. Generative models such as GPT, Claude, and Copilot not only adapt learning content but actively create new educational material. This requires a fundamentally new understanding of their pedagogical role.

As a result, AIED is transforming from a reproductive environment into one of shared cognitive partnership between humans and digital agents.

5.1.2 HYBRID INTELLIGENCE AS A CONCEPTUAL FRAMEWORK FOR AI INTEGRATION IN EDUCATION

The traditional view of AI as an autonomous system is gradually being replaced by the concept of hybrid intelligence, in which AI does not replace the human but enhances cognitive capabilities. This approach is based on the idea of synergy: human intuition, creativity, and ethical judgment are combined with the computational power, analytical speed, and adaptability of AI.

M. Cukurova notes that human – AI hybrid interaction is one of the key trends in educational technology. They emphasize that effective learning systems should function as extended learning environments in which AI acts not just as a knowledge mediator but as a partner in problem-solving, reflection, and self-directed learning [5].

In the context of vocational and technical education, hybrid intelligence is realized through:

– automated assessment with expert correction;

– interactive learning systems that model behavior and provide feedback;

– joint project development between students and digital agents, e.g., during code creation, diagram design, or data modeling [6].

5.1.3 ETHICAL AND INCLUSIVE DIMENSIONS OF AIED

As the influence of AI in education expands, the issue of ethical responsibility becomes increasingly important. The integration of AI changes both pedagogical approaches and the relationships among teachers, students, and digital agents. Therefore, there is a growing need to establish an ethical framework for AIED use.

According to W. Holmes et al., the main risks associated with AIED include [4]:

– algorithmic opacity and the inability to explain system-generated recommendations;

– hidden bias due to skewed training data;

– privacy violations and irresponsible collection of personal educational data;

– reduced student autonomy, with a risk of turning education into an overly controlled process.

In addition, issues of digital equity are critically important. Studies conducted within our project confirm that not all learners have equal access to modern digital tools and high-speed internet, particularly under war conditions or in socioeconomically disadvantaged regions.

Leading organizations such as UNESCO, IEEE, and the European Commission – recommend adhering to the following principles in AI integration:

– transparency (AI systems should be interpretable to users);

– fairness (avoiding discrimination or exclusion);

– accountability (clear assignment of responsibility for AI actions);

– security (protection of educational data);

– human-centeredness (AI should serve as a support tool, not a control mechanism) [7, 8].

5.1.4 THEORY OF SOCIALLY GENERATIVE SYSTEMS

A novel direction in AI and education research is the concept of socially generative systems, which views AI not as a static tool but as a co-participant in the social learning process.

M. Sharples proposes interpreting generative models (such as ChatGPT, Claude AI, and Copilot) as communication participants capable of supporting, transforming, or even simulating pedagogical interactions. Learning, in this context, becomes a triadic process: teacher – student – Ai [9].

Social generativity is reflected in:

– AI participation in dialogues, where it not only answers but also asks clarifying questions or provides counterarguments;

– co-construction of knowledge, where students "discuss" ideas with AI, refine arguments, and train logical thinking;

– shaping learning behavior through AI-generated recommendations that influence time planning or learning strategies.

This theory helps explain why perceived benefits of AI among teachers and students are interrelated. In our research, a network structure of perceived benefits was identified, where effects such as personalization, motivation, and innovation are interconnected. This is a manifestation of social generativity.

Thus, treating AI as a social agent allows us to expand traditional educational models and align them with 21^{st}-century learning concepts – co-creation, partnership, and multidirectional interaction [10, 11].

5.1.5 DIGITALIZATION AS A DRIVER OF PROFESSIONAL COMPETENCE DEVELOPMENT

Digital transformation affects not only educational tools but also the structure of professional competencies formed in students of technical disciplines. The focus is shifting from traditional knowledge and skills to integrated digital abilities, the capacity to adapt to emerging technologies, and the ability to collaborate effectively within digital environments.

A recent framework for vocational and technical education argues that developing digital competencies effectively requires a whole-institution approach – engaging institutional leaders, teachers, and learners together in co-creating the digital learning environment.

Systematic reviews in higher education point out that digital transformation demands not only technical fluency but also pedagogical skillsets: critical media literacy, ethical awareness, and methodological innovation are highlighted as essential capabilities for both students and educators.

A study on graduates' employability reveals significant skills gaps: employers increasingly require data literacy, online research competence, digital communication, and basic cybersecurity.

According to research conducted within our project (**Section 5.3**), both students and instructors acknowledge that the use of AI services contributes significantly to the development of key professional competencies (**Fig.5.1**), including:

– analytical thinking, developed through working with large datasets, querying AI, and interpreting results;

– digital literacy, enhanced through hands-on interaction with modern tools such as GitHub Copilot, Notion AI, and similar platforms [6, 11];

– adaptability and flexibility, fostered by navigating the unpredictability of generative AI responses;

– project-oriented thinking, supported by new formats such as learning case studies, hackathons, and collaborative work environments [12, 13].

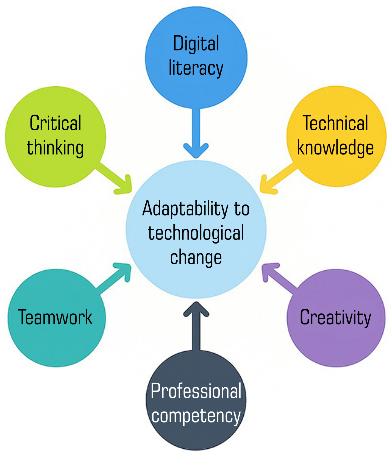

Fig. 5.1 Structure of the relationship between digital skills and components of professional competence

In the context of technical and vocational education, these competencies are especially important. Future professionals are expected not only to operate AI tools, but also to understand their architecture, ethical limitations, and practical relevance to their field of expertise [14, 15].

5.1.6 THE LIFELONG LEARNING PARADIGM IN THE DIGITAL SOCIETY

In the 21st century, the concept of lifelong learning has evolved from an abstract ideal into a practical necessity. The rapid advancement of digital technologies, particularly artificial intelligence, is reshaping the labor market, altering the qualifications expected from professionals, and shortening the life cycle of knowledge. In this context, higher education institutions are no longer limited to delivering foundational knowledge but are increasingly responsible for developing skills in self-directed learning, re-skilling, and critical adaptation (**Fig.5.2**).

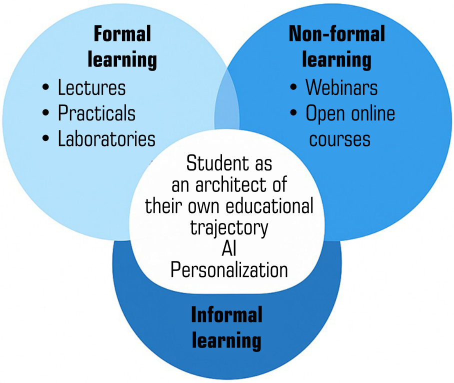

Fig. 5.2 Cross-structure of formal, non-formal, and informal learning in the digital society

New expectations for graduates of technical universities include:
– the ability to quickly update professional knowledge;
– readiness to master new digital tools independently, without external assistance;
– self-assessment skills for tracking one’s educational progress;
– intrinsic motivation for continuous learning, especially in online environments [16, 17].

Artificial intelligence plays a key role in supporting lifelong learning through:
– adaptive learning systems, which adjust content and pace based on learner performance;
– personalized learning pathways, aligned with learner goals and current competencies;

– AI-based assistants that provide suggestions, generate explanations, or administer diagnostic tests (e.g., Copilot, recommender systems used by platforms like Coursera);

– knowledge verification tools based on intelligent testing algorithms [18].

This shift requires a rethinking of both educational content and methodologies. Educators are now expected to cultivate learning-to-learn strategies, enabling students to function effectively in dynamic, digital knowledge environments.

5.1.7 TRANSFORMATION OF THE EDUCATIONAL ENVIRONMENT IN THE CONTEXT OF DIGITAL TRANSITION

As digital technologies continue to expand, the educational environment of technical universities is transforming into a multi-dimensional ecosystem that combines physical, virtual, blended, and simulated learning spaces. Within this evolving context, artificial intelligence functions as a modulator of educational flows, enabling the customization of learning processes to meet the individual needs of each participant.

Key characteristics of the modern educational environment include:

– hybrid learning formats, combining offline instruction, online learning, asynchronous modules, and simulation-based experiences;

– digital mobility, where students access content via mobile apps, cloud platforms, and virtual laboratories;

– integration of intelligent systems, such as AI-powered scheduling tools, progress tracking dashboards, and personalized recommendation engines;

– continuous feedback loops, supported by learning management systems (LMS), chatbots, and educational analytics platforms [4, 5].

Examples of integrated solutions:

– Moodle with AI modules – for participation analytics and automatic generation of personalized assignments;

– MS Teams with Copilot – assisting instructors in creating quizzes, answering student questions, and managing course materials;

– Open edX with adaptive pathways – delivering differentiated instruction based on learner performance and preferences.

This transformation redefines the educational space from a static location into a dy-namic learning ecosystem, responsive to changes in learner behavior and technological advan-cements.

The **Fig. 5.3** illustrates how core elements of the digital environment – administrative platforms, learning platforms, cloud services, simulators, and AI modules – interact through a central educational analytics hub.

This hub collects data on user activity, performance, and learning dynamics to generate individualized educational scenarios.

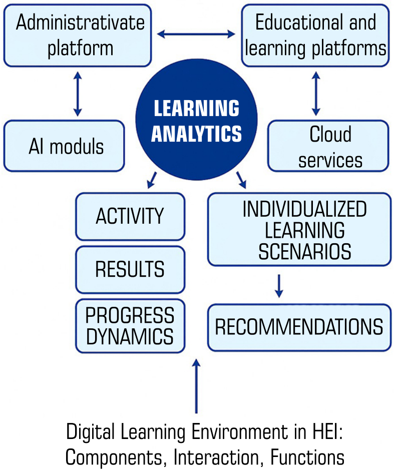

Fig. 5.3 Digital learning environment of a technical university: components, interactions, and functions

5.1.8 ADAPTING THE REGULATORY FRAMEWORK FOR AI INTEGRATION IN EDUCATION

The growing integration of artificial intelligence into educational processes requires not only technical modernization but also the updating of regulatory frameworks governing the operation of technical higher education institutions. At both national and institutional levels, the lack of clearly defined policies regarding the use of generative AI, student data analysis, and automated assessment systems creates legal uncertainty and raises concerns over academic integrity.

The model (**Fig. 5.4**) outlines regulatory alignment at three interconnected levels: national policy (macro), institutional governance (meso), and classroom practices (micro). It reflects how top-down and bottom-up regulatory dynamics shape ethical, transparent, and effective use of AI in education.

Key areas for regulatory adaptation include:

– institutional AI policies: formalizing guidelines for the permitted use of AI tools in student projects, theses, laboratory reports, and other academic work;

– revised assessment procedures: incorporating open formats, elements of oral verification, and hybrid assessment models to ensure authenticity of learning outcomes;

– ethical code of AI usage: requiring proper attribution for AI-assisted content (similar to academic citations), and prohibiting the use of AI for cheating, manipulation, or data fabrication.

Student data protection: aligning institutional practices with GDPR principles, even for internal data platforms used for educational analytics [19, 20].

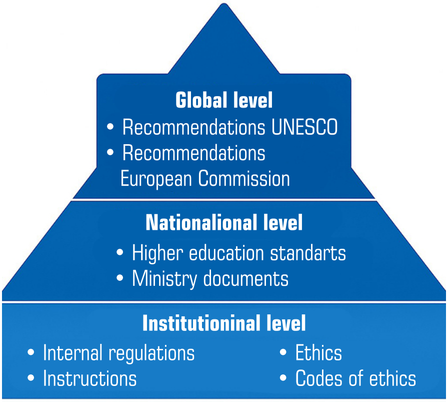

Fig. 5.4 Three-tier model of regulatory adaptation for AI integration into educational processes

Updating regulatory instruments is essential to ensuring ethical, transparent, and responsible integration of AI in higher education and maintaining trust among students, educators, and institutions.

5.1.9 DEVELOPING A DIGITAL TEACHING CULTURE IN THE AGE OF ARTIFICIAL INTELLIGENCE

The digital transformation of education is rapidly reshaping the role of educators. In the age of artificial intelligence (AI), teachers are no longer the sole providers of knowledge; they now act as mediators between learners and complex digital ecosystems, including AI-driven tools and platforms. This transition requires not only mastery of new technologies but also a profound shift in the professional identity of the teacher.

Key elements of this evolving identity include:

– critical reflection on AI capabilities: understanding the limitations and risks of automated assessment, as well as the impact of AI on learner autonomy and decision-making;

– eEthical awareness: recognizing the teacher's responsibility in shaping student attitudes toward responsible AI use and data ethics;

– readiness for co-creation: using AI as a tool for generating ideas, analyzing sources, and encouraging interdisciplinary thinking and collaboration.

Markers of a mature digital teaching culture include:

– the ability to blend AI tools with traditional pedagogical practices effectively;

– open dialogue with students about acceptable and ethical AI use in academic contexts;

– the development of original, AI-integrated course content tailored to discipline-specific needs;

– promotion of digital inclusivity, ensuring that AI-enhanced learning accommodates diverse learner needs.

In this context, fostering a digital teaching culture is not merely about acquiring technical skills; it is about reshaping educational values, empowering lifelong learning, and positioning educators as ethical leaders in a technology-rich academic environment.

The **Fig. 5.5** illustrates five progressive levels of digital maturity, from the most basic ("Digital Resistance") to the most advanced ("AI-Innovation Leadership"). It emphasizes that full integration of AI in education is only possible when institutions shift from mere technical adaptation to deep pedagogical rethinking.

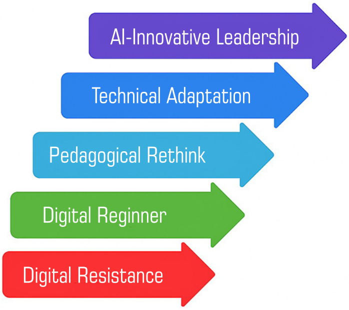

Fig. 5.5 Stages of digital maturity among university instructors in the context of AI integration

5.1.10 COMMUNITIES OF PRACTICE AND COLLECTIVE LEARNING AMONG INSTRUCTORS IN THE FIELD OF AI

The successful integration of artificial intelligence into education relies not only on individual digital competencies but also on the presence of collaborative professional ecosystems. These ecosystems enable instructors to acquire new knowledge, exchange experiences, critically reflect on pedagogical strategies, and co-develop innovative solutions. In this regard, communities of practice (CoPs) play a main role.

The **Fig. 5.6** presents a networked structure of collaboration among instructors, mentor hubs (mo-derators), external experts (industry representatives), and digital platforms. This configuration supports continuous collective learning and shared professional development in the field of AI in education.

Key characteristics of communities of practice and collective learning among instructors in the field of AI include:

– voluntary participation and horizontal collaboration rather than top-down mandates;

– a shared focus on the practical application of AI tools in teaching, research, and curriculum design;
– a safe environment for experimentation, dialogue, and learning from mistakes;
– development of a meta-perspective, where technologies are examined in broader educational, ethical, and social contexts.

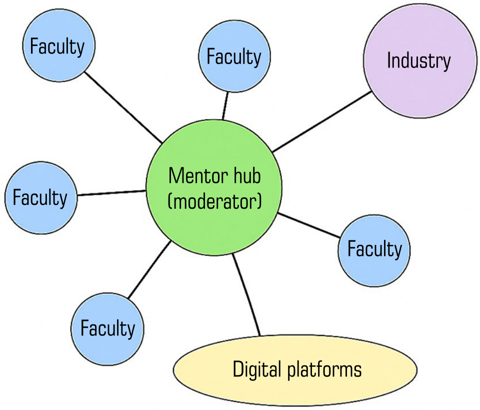

Fig. 5.6 Community of practice: interaction architecture for instructors in an AI-enhanced educational environment

Faculty at technical universities who engage in CoPs tend to adopt new tools more rapidly, adapt teaching materials, and generate AI-driven innovations in instruction [21].

Examples from Lviv Polytechnic National University include:
– cross-departmental workshops on ChatGPT, GitHub Copilot, and Midjourney;
– topic-specific groups in Microsoft Teams and Slack for exchanging AI teaching scenarios;
– summer schools on digital pedagogy, including micro-projects using generative AI;
– collaborative development of open educational resources (OERs) that incorporate AI components.

These initiatives foster a culture of continuous improvement and innovation, helping instructors transition from AI users to AI co-creators in their educational practice.

CONCLUSIONS TO SECTION 5.1

In modern technical universities, the integration of artificial intelligence (AI) requires not only digital modernization but a systemic transformation of the entire educational ecosystem. As shown in this chapter, the effective use of AI in higher education depends on several interconnected factors:

– multi-level support for the digital competence of instructors, encompassing both formal (professional development courses) and informal (communities of practice) learning;

– implementation of personalized professional development pathways, tailored to each educator's level of digital literacy, subject specialization, and teaching experience;

– creation of pedagogical autonomy spaces, where instructors are encouraged to experiment, share practices, and collaboratively adapt AI tools for diverse educational contexts;

– administrative support and local infrastructure, enabling rapid testing and scaling of educational innovations;

– integration of AI across all domains of academic activity, including content development, assessment, student guidance, and scientific research.

Ultimately, the educator is the key driver of transformation. Their experience, adaptability, and capacity for interdisciplinary collaboration are the foundation for sustainable digital evolution in technical higher education institutions.

5.2 ARTIFICIAL INTELLIGENCE AS A COMPONENT OF MODERN PROFESSIONAL TRAINING

In today's educational environment, AI is viewed not only as a subject of academic study but also as a tool that transforms professional training in higher education. This is particularly important for technical universities, where the integration of cutting-edge digital technologies is essential for maintaining the quality of academic programs.

Preparing professionals who can both apply and critically assess AI technologies requires embedding artificial intelligence into curricula, developing new courses, and using AI-based tools to optimize the educational process.

According to many researchers, one of the core competencies of the 21st century is AI literacy – a basic understanding of how AI systems function, their application areas, ethical concerns, and their ability to automate engineering, management, analytical, and creative tasks.

Common applications of AI in technical universities include:

– adaptive learning: platforms like Coursera and Khan Academy that incorporate AI-supported adaptive modules can tailor content delivery to each student's knowledge level [22];

– automated assessment: AI tools can automatically verify solutions in programming code, engineering problem-solving, and even open-ended questions [23];

– generative AI tools: ChatGPT, GitHub Copilot, and Claude AI are now widely used by students for generating examples, testing ideas, and checking hypotheses [24];

– virtual laboratories: the integration of AI and digital twins allows simulation of processes, especially in fields like Mechatronics, Automation, and Civil Engineering [25];

– intelligent tutors: AI agents assist students 24/7 by answering questions, providing feedback, and adjusting learning paths [26].

However, successful AI integration depends not only on technical infrastructure but also on teachers' willingness to rethink pedagogy and redefine their role in an automated educational setting. The teacher must act as a facilitator of human competencies such as critical thinking, ethical reasoning, and creativity, which complement the functions of Ai [27].

Therefore, artificial intelligence does not replace professional education but enhances it with new forms, greater flexibility, and effective tools. Its integration into the educational process enables technical education not only to respond to contemporary challenges but to set new standards for quality and practice-oriented learning [28].

According to the survey results, the most important digital competency identified by respondents as essential for an effective educational process is proficiency in using digital tools (rank – 4.56). The next priorities include personal data protection (4.25) and cybersecurity (4.10). Lower scores were assigned to competencies such as digital content creation (3.76) and providing online consultations (3.47), which indicates the need for greater attention to these areas in educational programs (**Fig. 5.7**).

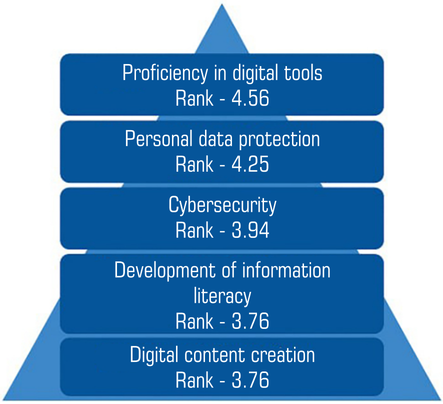

Fig. 5.7 Average ranks of digital competencies for professional education

The highest self-assessment among students was observed in the use of generative AI tools (such as ChatGPT and Copilot), with an average score of 4.8, reflecting strong practical interest and easy access to these technologies. In contrast, the lowest score was given to the understanding of AI ethics – only 3.2 points – indicating limited awareness of the normative and ethical aspects of AI use in education. This highlights the need to strengthen interdisciplinary courses on digital ethics and promote critical thinking in the application of intelligent systems (**Fig. 5.8**).

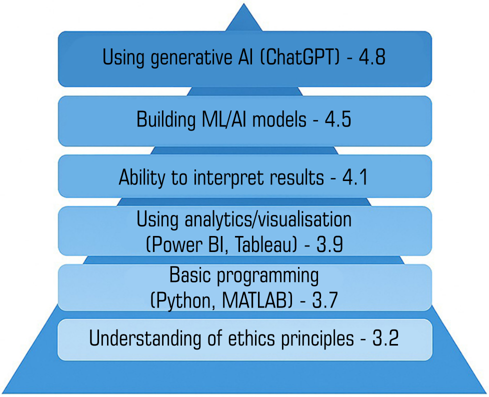

Fig. 5.8 Levels of digital and AI competencies among students in technical fields

CONCLUSION TO SECTION 5.2

Artificial intelligence is no longer a future concept but a present-day necessity in professional training. As this section has shown, AI serves not only as a subject of academic study but also as a transformative tool that redefines learning processes, roles of educators, and student engagement. In technical universities, where adaptability and innovation are key, the integration of AI enables more personalized, efficient, and relevant education. However, its successful adoption requires more than infrastructure – it demands a shift in mindset, pedagogical strategies, and ethical awareness. By embedding AI into the educational ecosystem, institutions prepare future professionals to operate responsibly and effectively in a rapidly evolving digital world.

5.3 PRACTICES OF AI INTEGRATION INTO THE EDUCATIONAL PROCESS AT LVIV POLYTECHNIC

Lviv Polytechnic National University is one of Ukraine's leading technical higher education institutions, actively promoting the digital transformation of education [29]. Under the leadership of Rector Nataliia Shakhovska – a recognized expert in the field of intelligent information technologies – the university has taken decisive steps to integrate artificial intelligence into its educational process, research activities, and interdisciplinary projects [30–33].

Lviv Polytechnic National University has expanded its AI-oriented initiatives through deep collaboration with major IT companies in the region. For example, partnerships with SoftServe, EPAM, ELEKS, GlobalLogic, N-iX, Intellias and others – many of which are headquartered or maintain significant offices in Lviv – have been central to this effort. These alliances have shaped curriculum and lab offerings: SoftServe and peers actively contributed to developing new AI, data science, cybersecurity, and IoT programs through the Lviv IT Cluster, with support for educational tracks and access to industry-grade tools.

Events like the Lviv IT Cluster's "IT Future Conf" with SoftServe as gold partner regularly assemble leading firms (including EPAM, N-iX, Avenga, Intellias) for lectures, workshops, and student recruitment. Beyond education, companies like SoftServe have launched real-world AI pilot programs such as integrating generative AI into development workflows, boosting productivity up to 45% creating internship and research opportunities for students at Lviv Polytechnic .

Additionally, joint spaces like the SmartIndustry conference and the IoT lab, supported by both the IT Cluster and companies like SoftServe and GlobalLogic, foster continuous collaboration among academia, business, and students. This engagement enables the university to co-create applied AI solutions, while students benefit from hands-on projects, industry mentoring, and direct paths to employment.

The key stakeholder groups – students, instructors, administration, IT departments, and external partners (IT companies, EdTech developers) – and the directions of their interaction during digital transformation are presented in **Fig 5.9**.

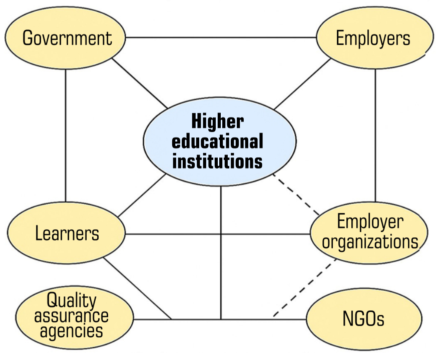

Fig. 5.9 Network structure of stakeholder interaction in the process of AI integration into technical higher education

Instructors serve as intermediaries between the administration and students, while also collaborating with IT companies in the development of educational content. Students interact not only with instructors, but also indirectly – through LMS interfaces – with technical services.

This network structure highlights that successful AI implementation in education is not merely a technological shift, but an organizational one, where coordination among all educational environment participants plays a crucial role.

5.3.1 INTEGRATION OF AI INTO ACADEMIC COURSES

The development of digital and AI-related competences is supported through a set of dedicated courses introduced into the academic curriculum, such as:

1. Artificial Intelligence, Machine Learning, and Intelligent Data Analysis – offered to students in programs like Computer Science (122), Software Engineering (121), Applied Mathematics (113), and Information Systems (126).

2. Foundations of AI and Digital Transformation – available as an elective for students from non-technical fields.

3. Decision Support Systems, Python Programming, and Neural Networks and Computational Intelligence – included in master's programs.

Some courses are co-designed in collaboration with leading IT companies such as SoftServe and EPAM [34]. This partnership facilitates the inclusion of industry-oriented content and enables students to work with real-life case studies.

5.3.2 DIGITAL LEARNING ENVIRONMENTS ENHANCED BY AI TOOLS

Lviv Polytechnic National University actively employs blended learning platforms, particularly Moodle, which is integrated with analytics modules and predictive algorithms [35]. In pilot settings, the university has introduced:

– automated code assessment systems;
– pattern recognition in student responses;
– generation of personalized assignments using generative AI.

Tools such as ChatGPT, GitHub Copilot, and Notion AI are increasingly used by students to assist in study preparation, solution modeling, writing reflections, and preparing presentations.

Personalized learning systems using neural networks have demonstrated success in adapting individual study plans for technical students [36]. Furthermore, the use of sentiment analysis and neural-network quality-management tools in education and healthcare has been validated in similar educational settings [37–39].

According to the survey results [**Fig. 5.10**], the most widely recognized benefit associated with the use of AI in professional education is personalized learning (84%). This indicates a strong demand for individual learning paths supported by intelligent systems.

Other significant factors include improved quality of education (75%) and the development of digital skills (66%).

Less than half of the respondents identified assessment optimization (39%) as a key benefit, which may reflect a lack of awareness about the technical capabilities of AI in knowledge evaluation.

In response, instructors have developed new assessment formats – including analytical reports, mini-projects, and case studies – aimed at fostering critical thinking and promoting deeper learning.

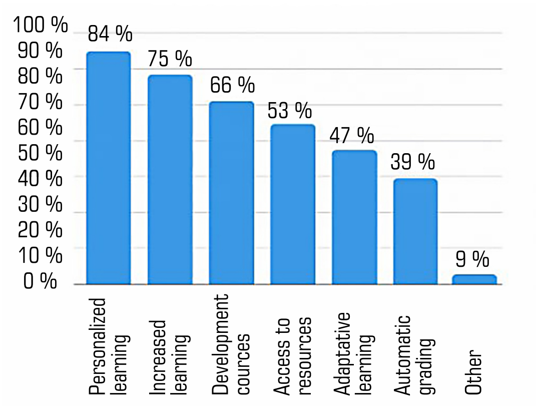

Fig. 5.10 Survey results on the perceived benefits of using artificial intelligence in professional education

The **Fig. 5.11** illustrates how many AI-related benefits each respondent selected. Most respondents identified five to seven key advantages, indicating a broad perception of AI's value within the student community. This distribution reflects a high level of awareness among participants regarding the diverse potential of AI in education, particularly in areas such as adaptive learning, AI ethics, and big data analytics.

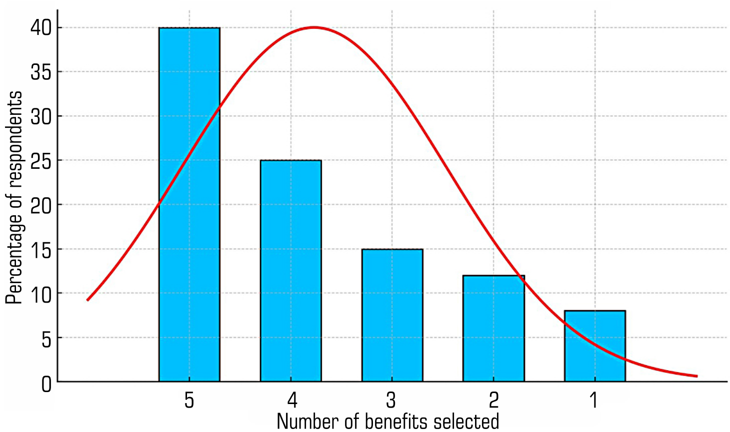

Fig. 5.11 Distribution of the number of AI benefits selected by respondents

CHAPTER 5

5.3.3 STUDENT INITIATIVES AND RESEARCH PROJECTS

Lviv Polytechnic National University actively supports youth-led research initiatives related to artificial intelligence. University-organized AI hackathons, startup competitions, and cross-faculty innovation hubs engage students in developing projects in areas such as:

– smart city technologies;

– energy efficiency;

– digital assistants;

– educational platforms with adaptive learning features.

Some student theses and master's projects already implement ML algorithms using tools such as TensorFlow, scikit-learn, and OpenCV, demonstrating the gradual integration of AI into students' professional skill sets during their studies [40].

At the same time, pedagogical research at Lviv Polytechnic National University highlights the role of educational coaching and interdisciplinary learning in enhancing student motivation and cognitive engagement. Studies show that activating students' learning potential through coaching methods and integrating foreign language instruction within professional education contributes to higher autonomy and readiness for digital learning environments.

5.3.4 INTERNATIONAL PROJECTS AND COLLABORATIONS

Lviv Polytechnic National University actively participates in a range of international educational initiatives that support the integration of artificial intelligence and digital transformation into higher education. Among them are the Erasmus+ Jean Monnet projects focused on the digitalization of governance and education in Ukraine, as well as the Baltic University Programme, which promotes sustainable development modeling using analytical and AI-based tools.

Additionally, the university is involved in specialized Erasmus+ Key Action 2 (KA2) consortia, such as:

– "Effectiveness of Medicine E-learning Distance Courses", an international collaborative project co-led by Prof. N. Shakhovska in partnership with the University Lumière Lyon 2 (France), the Polytechnic University of Valencia (Spain), Linnaeus University (Sweden), and others. This project focuses on the application of AI-based adaptive learning systems in medical education and digital pedagogy;

– "iCare4Next" emphasizes inclusive digital learning, accessibility, and digital support mechanisms for students with disabilities and veterans. AI is used in this context to develop intelligent tutoring and support systems that adapt to users' cognitive and emotional states;

– "SmallAIM (AI in Medicine)", coordinated under the Eurizone initiative, explores the application of explainable AI models in medical diagnostics and e-learning systems, integrating ethical considerations and transparency.

These international collaborations not only raise awareness about the potential of artificial intelligence among students and faculty but also enable the transfer of innovative instructional approaches into the Ukrainian educational context. Through such projects, Lviv Polytechnic National University contributes to the formation of a shared European educational space based on digital inclusion, sustainability, and data-driven pedagogy.

5.3.5 INDUSTRY-SUPPORTED EDUCATIONAL PROGRAMS: THE CASE OF LVIV IT CLUSTER

In response to the growing demand for industry-relevant competencies, Lviv Polytechnic National University has partnered with the Lviv IT Cluster to modernize its bachelor's degree programs.

This collaboration resulted in the creation and implementation of cutting-edge curricula across multiple disciplines, reflecting the latest trends in artificial intelligence, digital systems, and data analytics.

The updated programs include:

– Robotics (G6 Information-Measuring Technologies) – targeting applications in medicine, defense, and space;

– Internet of Things (F3 Computer Sciences, Systems Engineering) – training specialists to design smart, internet-connected systems;

– Cybersecurity (F5 Cybersecurity and Information Protection) – preparing experts to protect digital infrastructure;

– Artificial Intelligence (F3 Computer Sciences, AI Systems) – focusing on developing AI-based technologies and applications;

– DevOps & Data Engineering (F6 Information Systems and Technologies) – teaching students how to manage complex digital ecosystems;

– Business Analysis & Data Science (F4 System Analysis) – equipping future professionals with analytical and decision-making skills;

– IT Sales Management (F4 System Analysis, IT Product Management) – training students in product management and market strategies;

– UI/UX Design (G20 Publishing and Polygraphy) – merging technology with aesthetics to create user-centered interfaces.

These programs are developed with the active participation of IT professionals and regularly updated to reflect the needs of the digital labor market. Thanks to this initiative, students gain access not only to up-to-date theoretical knowledge but also to real-world practices and internships with partner companies.

CONCLUSION TO SECTION 5.3

The implementation of artificial intelligence at Lviv Polytechnic National University exemplifies a strategic and comprehensive approach to educational innovation. Through the integration of

AI-related courses, the use of intelligent digital learning environments, and active engagement in international projects, the university has established itself as a leader in fostering AI competencies among both students and faculty.

Importantly, these initiatives go beyond technology adoption – they reshape the pedagogical culture, stimulate interdisciplinary collaboration, and align educational outcomes with the demands of the digital economy. The ongoing institutional commitment to AI-driven transformation reflects not only current global trends but also a proactive vision for the future of technical education.

5.4 CHALLENGES AND ETHICAL ASPECTS OF USING AI IN THE EDUCATIONAL PROCESS

Despite the numerous benefits that artificial intelligence technologies bring to professional higher education, their implementation is accompanied by a range of challenges: technical, pedagogical, and ethical. In technical universities, where AI is used not only as a learning tool but also as a component of professional practice, the issue of responsible AI use becomes particularly important.

5.4.1 ACADEMIC INTEGRITY IN THE AGE OF GENERATIVE AI

One of the most debated challenges is the use of generative AI models (such as ChatGPT, Claude, and GitHub Copilot) by students to produce texts, answers, code, or reports. In the absence of clearly defined policies on AI usage in higher education, several risks arise:

– academic plagiarism;
– loss of independent critical thinking skills;
– automation of tasks without real understanding of the content.

In response to these risks, instructors at Lviv Polytechnic are developing new assessment formats: analytical tasks with personalized elements, open-ended discussions, and mini-projects that require students to justify their thought processes. There is also ongoing debate around acceptable AI usage, aiming to distinguish between responsible assistance and inappropriate substitution of human work.

5.4.2 SURVEY RESULTS ON BARRIERS TO AI ADOPTION

To identify barriers to the effective integration of AI into professional education, a survey was conducted among students and faculty of technical disciplines. The results are presented in **Fig. 5.12**.

The most significant barrier, according to respondents, is the lack of appropriate user skills (65%), highlighting the urgent need for systematic training of both students and instructors. A considerable percentage also emphasized ethical risks (53%) and technical infrastructure limitations (49%).

Other barriers, such as lack of funding (45%) and legal constraints (18%), point to the importance of external support and regulatory frameworks for the integration of digital innovations in education.

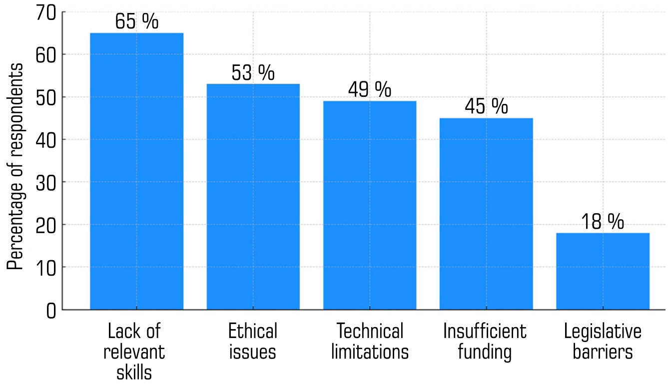

Fig. 5.12 Survey results on barriers to the use of artificial intelligence in the educational process

5.4.3 PERCEPTION OF PROBLEM COMPLEXITY: HOW MANY BARRIERS DO RESPONDENTS IDENTIFY?

The **Fig. 5.13** illustrates how many barriers each respondent marked as significant. This allows us to assess whether the problem of AI integration in education is perceived narrowly or broadly by stakeholders.

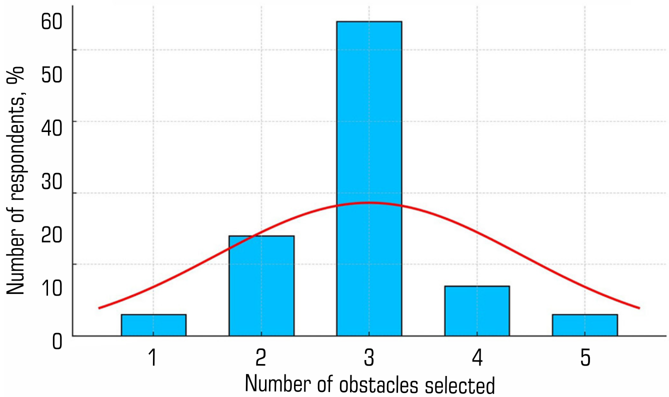

Fig. 5.13 Distribution of the number of AI-related barriers identified by respondents

The data suggest a near-normal distribution: most respondents selected three key barriers, indicating a balanced and comprehensive perception of the issue. A small portion identified only one or as many as five barriers, reflecting varying levels of awareness or personal experience with AI integration in education. This distribution underscores the need for a differentiated approach to addressing these challenges – from basic training to institution-wide support policies.

5.4.4 DIGITAL ACCESS INEQUALITY

Not all learners have equal access to modern digital tools or stable internet connections – particularly under wartime conditions or in blended/remote learning settings. This raises concerns that the integration of AI technologies may deepen educational inequality.

In this context, it is crucial for universities to provide:

– open-access resources and local servers with AI capabilities (within internal infrastructure);

– baseline digital literacy training for all students regardless of major;

– onboarding sessions on using AI tools (e.g., Notion AI, Copilot, OpenCV, RapidMiner) at the beginning of the academic year.

5.4.5 INSTRUCTOR TRAINING AND SUPPORT

The successful integration of AI requires not only technical upgrades but also a shift in the role of instructors. Not all educators possess sufficient experience with digital tools, which can lead to:

– anxiety about new technologies;

– challenges in managing the learning process;

– resistance to change due to lack of support or increased workload.

Lviv Polytechnic gradually implements professional development programs in EdTech, digital pedagogy, and AI tools. These include training workshops, summer schools, and involvement of faculty in cross-departmental digitalization projects.

5.4.6 ETHICAL USE OF AI IN EDUCATION

There is growing global attention to AI ethics. Key principles that educational institutions should adhere to include:

– algorithmic transparency (understanding how AI systems make decisions);

– non-discrimination (eliminating bias in data or models);

– data protection (especially when analyzing student performance or handling personal data);

– respect for human autonomy (AI as an assistive tool, not a replacement for human input).

Universities adopting AI should develop their own ethical guidelines for digital tools, clearly defining boundaries, accountability, confidentiality, and openness.

CONCLUSION TO SECTION 5.4

The integration of artificial intelligence into the educational process of technical universities brings both transformative opportunities and critical challenges. While AI can significantly enhance learning personalization, content generation, and data-driven decision-making, its implementation must be approached with caution and responsibility. The findings indicate that insufficient user skills, ethical concerns, and infrastructure limitations remain key barriers to effective AI adoption. Moreover, unequal digital access, lack of instructor preparedness, and the potential erosion of academic integrity due to misuse of generative AI tools highlight the need for institutional strategies that combine technical, pedagogical, and ethical safeguards. Universities must therefore not only invest in digital infrastructure and professional development but also establish transparent and inclusive policies to guide the responsible use of AI. By addressing these challenges through a holistic and equity-focused approach, higher education institutions can ensure that the integration of AI strengthens rather than undermines the quality and integrity of academic processes.

5.5 A MODEL FOR IMPLEMENTING AI IN PROFESSIONAL EDUCATION AT A TECHNICAL UNIVERSITY

Successful digital transformation of the educational process at technical higher education institutions requires not a fragmented adoption of individual digital tools, but a systematic model for integrating artificial intelligence (AI) into all stages of professional training. Such a model should be based on an interdisciplinary approach, practical orientation, adherence to ethical principles, and the development of both student and faculty digital competencies.

5.5.1 IMPLEMENTATION LEVELS

The model can be represented as a three-level structure:

a) Level 1 – AI literacy: development of basic knowledge about the principles of AI, machine learning, algorithms, and their societal impact. This level should be accessible to all students, regardless of their field of study.

Implementation methods: integrated lectures, online courses, and seminars;

b) Level 2 – professional application of AI: using AI as a tool within the framework of a specific discipline: for example, forecasting in economics, digital twins in mechanical engineering, data analysis in the energy sector, code generation and verification in IT.

Implementation: through specialized courses, laboratory work, and practical training;

c) Level 3 – research and innovation Level: engaging students in interdisciplinary research projects, hackathons, and thesis projects using AI technologies. Active collaboration with IT companies, participation in international educational initiatives, and submitting startup ideas to innovation competitions.

5.5.2 KEY COMPONENTS OF THE MODEL

Institutional Policy:

– defining a clear strategy for digital transformation;
– developing an ethical code for the use of AI in education;
– supporting educational initiatives at the rectorate level.

Educational Programs and Standards:

– updating academic programs to include AI-oriented components;
– designing interdisciplinary courses;
– implementing micro-qualifications and certification modules (e.g., AI for Engineers, AI for Teachers).

Faculty Development:

– offering professional development courses in AI/EdTech;
– facilitating experience exchange among departments and faculties;
– providing mentorship for junior faculty in working with digital tools.

Infrastructure:

– access to open resources (Google Colab, Hugging Face, Kaggle);
– availability of AI laboratories and GPU-supported servers;
– equipping classrooms for hybrid and simulation-based learning.

Integration with the Labor Market:

– collaboration with IT companies in program development;
– student internships in AI-focused teams;
– organization of workshops, guest lectures, and certifications involving industry professionals.

5.5.3 VISUALIZATION OF THE BENEFITS OF AI INTEGRATION

The multiple interconnections between the benefits of AI use in education are shown in **Fig. 5.14**.

The nodes with the highest number of associative connections are personalized learning, access to resources, and preparation for the digital labor market. This indicates that these components form the core perception of AI effectiveness in professional education. The Other node is linked by only a single edge, reflecting its limited significance. The thickness of the connecting lines represents the frequency with which respondents selected the connected benefits simultaneously.

These central nodes not only reflect user perceptions but also align with current academic and policy research. For instance, research in corporate technical training shows that digital transformation increasingly requires instructional designers to integrate digital tools within pedagogical design emphasizing adaptability, continuous improvement, and agile methodologies. Furthermore, the European VET agenda recognizes vocational education's leading role in bridging education and industry through the development of workplace-ready digital competences.

The 3D model clearly reveals clustering among the identified benefits (**Fig. 5.15**). For example, personalization, motivation, and teacher time optimization form a logical segment related to pedagogical impact. In contrast, access to resources and preparation for the labor market lean more toward functional and career-related advantages. The spatial structure highlights central nodes of influence and potential leverage points to amplify the effects of AI implementation through interconnected factors.

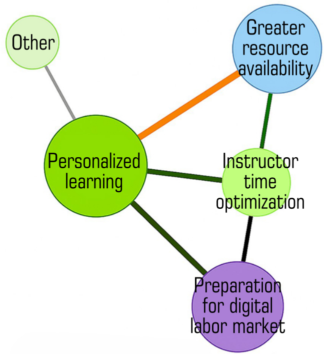

Fig. 5.14 Visualization of multiple interconnections between the benefits of AI use in education (2D)

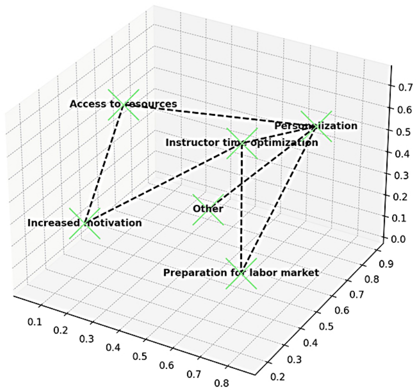

Fig. 5.15 Spatial visualization of associations between the benefits of AI use in education (3D graph)

5.5.4 EXPECTED OUTCOMES OF THE MODEL

The following results are expected from the proposed model:
– increased competitiveness of graduates in the global labor market;
– reduced gap between theoretical knowledge and practical application;
– development of a culture of ethical and responsible AI use;
– strengthening the university's role as a center for digital innovation;
– establishment of sustainable infrastructure to support AI-enhanced learning.

CONCLUSIONS TO SECTION 5.5

The proposed model for integrating artificial intelligence into professional education at a technical university highlights the need for a comprehensive, multi-level approach to digital transformation. It encompasses foundational AI literacy for all students, specialized professional applications, and innovative research activities. By addressing key components – institutional policy, curriculum modernization, faculty training, technical infrastructure, and integration with the labor market – the model supports the development of a resilient educational ecosystem. The visualization of AI-related benefits confirms that the most valued aspects include personalized learning, access to resources, and enhanced readiness for the digital labor market. The expected outcomes demonstrate the model's potential as a strategic tool for advancing the role of the technical university as a center of digital innovation.

CONCLUSIONS

The integration of artificial intelligence technologies into the professional training of students in higher technical education is not only a demand of the times but also a strategic necessity for ensuring quality, flexibility, and innovation in the educational process. Modern technical univer-sities – in particular, Lviv Polytechnic National University – demonstrate their readiness to act as drivers of digital transformation by combining academic tradition with technological advancement.

Under the leadership of Rector Nataliia Shakhovska, Lviv Polytechnic National University has been implemen-ting a consistent policy of digitalization. This policy is grounded in the expansion of digital competencies among students and faculty, the inclusion of AI components in educational programs, the development of an open digital infrastructure, and participation in international projects and partnerships with the business sector. This chapter has proposed a model for implementing artificial intelligence in technical higher education, which takes into account multilevel training, ethical challenges, institutional frame-works, and infrastructural conditions. The approach, based on a combination of AI literacy, practical application, and research engagement, enables the formation of not only competitive professionals but also responsible citizens capable of interacting effectively and ethically with emerging digital realities.

Future development prospects lie in enhancing teacher training systems for AI integration, adapting academic integrity policies to the new conditions, and designing interdisciplinary learning tracks that merge technical expertise, social competencies, and digital ethics.

APPENDIX A.

SURVEY QUESTIONNAIRE: ARTIFICIAL INTELLIGENCE IN HIGHER EDUCATION

This appendix contains the survey form developed specifically for students and academic staff of Lviv Polytechnic National University, aimed at studying their experience and perspectives on the integration of artificial intelligence (AI) into the educational process. While the questionnaire was initially tailored for the institutional context of Lviv Polytechnic, it is also applicable for use in other technical higher education institutions across Ukraine.

The questionnaire was designed to:

– identify the current level of AI adoption in academic activities;

– explore students' and lecturers' usage of AI tools in learning and teaching;

– assess perceived advantages and concerns regarding AI implementation;

– and determine the need for additional training or support related to AI technologies.

The structure of the survey includes both closed-ended questions for statistical analysis and open-ended responses for collecting individual insights and reflections. The results were used to inform the analysis and argumentation in **Sections 5.3.1**, **5.3.2**, and **5.3.5** of the monograph, contributing to a deeper understanding of the human dimension of digital transformation in technical education.

SURVEY ON THE USE OF ARTIFICIAL INTELLIGENCE IN VOCATIONAL AND HIGHER EDUCATION

1. Gender

- ☐ Female
- ☐ Male
- ☐ Other
- ☐ Prefer not to say

2. Age

- ☐ Under 18
- ☐ 18–24
- ☐ 25–34

- ☐ 35–44
- ☐ 45 and older

3. Status

- ☐ Vocational education student
- ☐ University student
- ☐ Teacher
- ☐ Administrator
- ☐ Other: ______________________________

4. Have you ever used artificial intelligence (AI) tools in your learning or teaching process?

- ☐ Yes
- ☐ No
- ☐ Not sure

5. If yes, which AI tools have you used? *(multiple choices allowed)*

- ☐ ChatGPT
- ☐ Grammarly
- ☐ Duolingo
- ☐ Khan Academy (AI tutor)
- ☐ AI-based learning platforms (e.g., Coursera, EdApp)
- ☐ AI-integrated LMS (e.g., Moodle with AI plug-ins)
- ☐ Other (please specify): ______________________________

6. What benefits of AI in education do you find most important? *(select up to 7)*

- ☐ Personalized learning
- ☐ Increased learning outcomes
- ☐ Development of courses and materials
- ☐ Access to high-quality resources
- ☐ Adaptive learning paths
- ☐ Automatic grading and feedback
- ☐ Assistance with disabilities
- ☐ Motivation and gamification features
- ☐ Support for self-paced learning
- ☐ Improvement of digital skills
- ☐ Other (please specify): ______________________________

7. How many AI-related benefits do you personally consider relevant in your experience?

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

- ☐ 6
- ☐ 7

8. What obstacles do you think hinder the implementation of AI in the educational process? *(multiple choices allowed)*

- ☐ Lack of relevant digital skills
- ☐ Ethical issues (e.g., plagiarism, fairness)
- ☐ Technical infrastructure limitations
- ☐ Insufficient funding
- ☐ Legal or regulatory barriers
- ☐ Lack of interest from faculty or administration
- ☐ Resistance to change
- ☐ Other (please specify): ____

9. How many obstacles do you personally see in the implementation of AI in the educational process?

- ☐ 0
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5 or more

COMMENTS (OPTIONAL)

____

If you have your own thoughts, suggestions, or ideas about the implementation of AI in higher education, please share them below:

____

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