QUALITY ASSURANCE OF VOCATIONAL AND PROFESSIONAL PRE-HIGHER EDUCATION IN THE CONTEXT OF CONTEMPORARY CHALLENGES

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QUALITY ASSURANCE OF VOCATIONAL AND PROFESSIONAL PRE-HIGHER EDUCATION IN THE CONTEXT OF CONTEMPORARY CHALLENGES

MONOGRAPH

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TABLE OF CONTENTS

PREFACE

The monograph “Quality assurance of vocational and professional pre-higher education in the context of contemporary challenges” was prepared by researchers from the National Academy of Educational Sciences of Ukraine in cooperation with and with editorial support from Polish colleagues from the Academy of Silesia. The publication reflects the results of interdisciplinary research and international scientific cooperation aimed at understanding the contemporary challenges of ensuring the quality of vocational and professional pre-higher education.

The importance of ensuring the quality of education in Ukraine is determined by the dynamics of changes in the labour market, the transnational mobility of students, digital transformation, and the need to develop sustainable education systems in post-crisis conditions. This phenomenon is examined taking into account theoretical and methodological approaches and national education policies aimed at human capital development, as well as the requirements of the European Quality Framework for Vocational Education and Training.

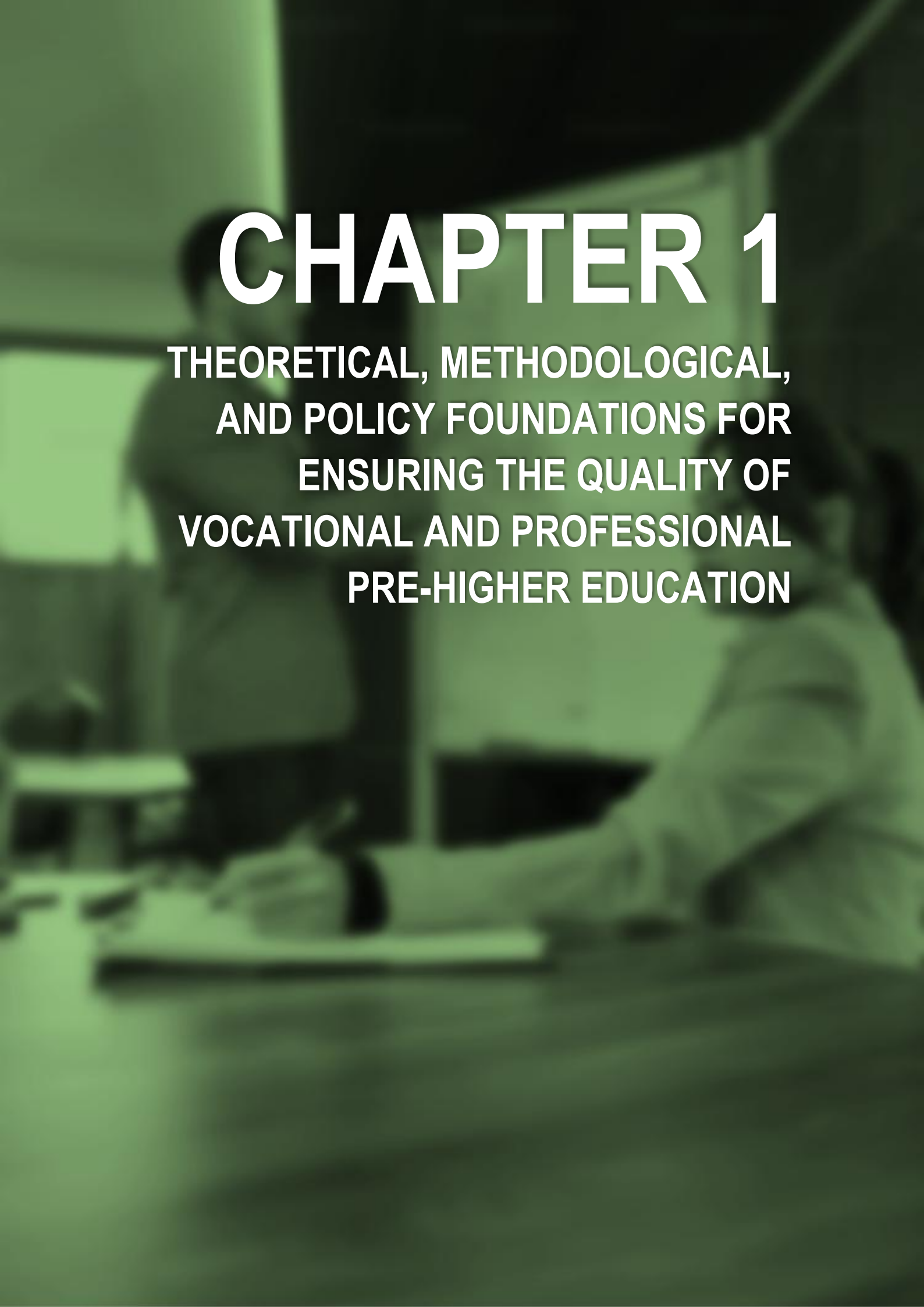
The sections of the monograph highlight institutional mechanisms and models for managing internal and external systems for ensuring the quality of vocational and professional pre-higher education, and substantiate the role of data-driven management, intelligent educational systems and artificial intelligence technologies in the modernisation of educational processes. Particular attention is paid to the recognition of learning outcomes, sustainable development priorities and sectoral aspects of training specialists in line with new economic needs, in particular the development of energy-efficient construction and green competencies.

The monograph also reveals a competency-based approach to the professional training of future specialists, the peculiarities of project-based learning and the integration of digital technologies into the educational and production environment. The socio-psychological and career dimensions are presented on the basis of an analysis of the agency of teaching staff, the modernisation of vocational guidance, career counselling and the development of professional culture as components of the continuous improvement of the quality of vocational and professional pre-higher education.

The publication is intended for researchers, education policy developers, education administrators, teachers, and stakeholders involved in the development and implementation of quality assurance systems. The monograph aims to promote academic discourse, support institutional change, and strengthen the integration of Ukraine's vocational and professional pre-higher education into the European Education Area.

The editors hope that the results presented in the publication will contribute to further research, the expansion of international cooperation and the implementation of evidence-based approaches to quality assurance in education.

Editors



CHAPTER 1

THEORETICAL, METHODOLOGICAL, AND POLICY FOUNDATIONS FOR ENSURING THE QUALITY OF VOCATIONAL AND PROFESSIONAL PRE-HIGHER EDUCATION

1.1. CONCEPTUAL FOUNDATIONS OF VOCATIONAL EDUCATION QUALITY: THE EVOLUTION OF APPROACHES WITHIN THE CONTEXT OF HUMAN CAPITAL TRANSFORMATION

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This chapter investigates the conceptual foundations of vocational education quality amidst contemporary challenges. It analyses the genesis of the "education quality" category, evolving from academic canons to a dynamic model that satisfies stakeholder needs through conditions, processes, and outcomes. The transformation of educational orientations is examined through the lens of human capital theory evolution, where cognitive flexibility and lifelong learning capacities remain priorities. The study identifies a mutual determination between investments and quality standards as a guarantor of the economic efficiency of professional training. The analysis demonstrates that the consolidation of the competence paradigm facilitates a transition toward assessing actual learning outcomes. Finally, the research outlines strategic development vectors for a holistic educational ecosystem – namely digitalisation, inclusivity, and foresight – underpinned by next-generation occupational standards and independent professional qualification assessment tools.

Keywords: *human capital, inclusivity, competence paradigm, occupational standards, digitalisation, vocational education quality*

The establishment of the conceptual foundations for vocational education quality is inextricably linked to the long-term evolution of scientific perspectives on the role of humans in economic processes, originating from the works of the classical school of political economy. In the 18th and 19th centuries, William Petty, Adam Smith, David Ricardo, and John Stuart Mill established the methodological foundation for understanding that a worker's skills and abilities significantly drive national wealth growth (Duga, 2025). Specifically, Adam Smith equated the acquired abilities of society members with fixed capital, noting that expenditures on education and vocational training constitute real investments subsequently recovered through higher labour productivity and corresponding earnings. This approach initiated the consideration of vocational education quality through its capacity to generate economic value, where a specialist's training level serves as a metric for their future efficiency. The subsequent stage of scientific thought, represented by neoclassicists Alfred Marshall and Irving Fisher, deepened this investment approach by viewing education as a

national investment that ensures long-term returns not only for the individual but for the state as a whole (Khimchenko & Liekh, 2019).

A profound conceptual revolution in defining the parameters of specialist training quality occurred in the mid-20th century, when Theodore Schultz and Gary Becker formalised human capital theory (Table 1.1).

Table 1.1. Evolution of Human Capital Content in the Context of Educational Demands

Historical Stage	Key Theorists	Interpretation of Education's Role	Quality Priority
Classical (18th–19th c.)	A. Smith, D. Ricardo, W. Petty	Education as a means to increase labour productivity	Acquisition of basic labour skills
Neoclassical (Early 20th c.)	A. Marshall, I. Fisher	Education as a long-term investment in a "national asset"	Alignment with occupational standards of the era
Formal (Mid-20th c.)	T. Schultz, G. Becker	Education as a source of capitalised individual income	Economic efficiency and ROI of training
Contemporary (Early 21st c.)	Knowledge economy representatives	Education as a foundation for cognitive flexibility and adaptability	Lifelong learning, digital, and soft skills

Schultz substantiated the proposition that human capital is a form of capital because it serves as a source of future earnings or satisfactions, and it is "human" because it constitutes an integral part of the individual. He defined human capital as the stock of knowledge, skills, experience, health, abilities, and energy inherent in every individual, proving the economic expediency of vocational training expenditures (Yalovyi, 2015). Within this context, education quality began to be interpreted as a process of asset accumulation, where every educational component must aim to increase the future specialist's market value. The genesis of this theory confirms that educational system development is a logical result of recognising the decisive role of intellectual resources in economic progress, where quality acts as a guarantor of the return on invested resources. The contemporary state of human capital theory is characterised by a transition from the quantitative accumulation of knowledge to the qualitative transformation of competencies amidst digitalisation and the shift toward a knowledge economy. Given the rapid obsolescence of knowledge, the human capital concept emphasises the importance of continuous lifelong learning. Thus, investments in vocational education are now directed not only toward obtaining primary qualifications but also toward

fostering an individual's adaptive potential, enabling them to remain competitive in the Industry 4.0 era.

The further development of human capital theory necessitates expanding its analytical framework, particularly by integrating competence-based, behavioural, and innovative approaches. Researchers focus primarily on cultivating so-called "meta-competencies" – the capacity for self-organisation, digital literacy, emotional intelligence, communication, and interdisciplinary interaction. These characteristics are increasingly viewed as key determinants of human capital efficiency, defining a worker's readiness to participate in high-tech production processes and adapt rapidly to innovative changes. Scientific literature emphasises that cultivating such universal competencies becomes possible only through the creation of a sophisticated educational ecosystem oriented toward the integration of formal, non-formal, and informal learning.

Simultaneously, modern human capital assessment models are gradually shifting from traditional econometric approaches toward complex indicators that account for the quality of the social environment, access to digital infrastructure, and levels of innovative activity. Approaches based on measuring the "creative" and "intellectual" potential of the population allow for a deeper investigation into the relationship between educational investments and economic development, highlighting the importance of social capital, network interactions, and trust. In this context, human capital is increasingly viewed as a dynamic system developing through interaction with technological, cultural, and institutional factors, while its efficiency is determined by the degree of human participation in innovative processes and social progress. Analysing the quality of vocational education requires a clear definition of this category, which modern scientific paradigms view as a multifaceted phenomenon encompassing philosophical, social, and economic aspects. Education quality is an integrative characteristic certifying an educational institution's ability to achieve established goals in specialist training while meeting defined state standards and stakeholder expectations. It is represented through the quality of life within society and acts as a recurrent phenomenon, where each stage of educational activity influences the next, forming a holistic result. According to international approaches, notably UNESCO and ISO (Centre for Academic Ethics and Excellence in Education "Ethos", 2019), quality in vocational training involves not only the final result (learner knowledge) but also processuality – the functioning of academic programmes, staffing, the state of material and technical facilities, and the internal educational environment.

The economic dimension of vocational education quality focuses on the degree to which actual learning outcomes align with market conditions and the investment attractiveness of a specific educational programme. This implies that quality is defined as the most effective use of human and material resources to prepare a specialist capable of immediate integration into production processes. Here, a mutual determination arises

between funding levels (investments) and quality standards: high standards require appropriate resource provision, while an effective quality assurance system guarantees the return on these investments based on high personnel qualifications (Sydorchenko, 2023). Furthermore, quality is viewed as the satisfaction of the needs of all educational service clients – the state, employers, and the learners themselves – where each possesses unique criteria for evaluating the outcome. Additionally, the economic approach to interpreting vocational education quality emphasises the importance of mechanisms for evaluating educational investment efficiency, including graduate employment rates, professional productivity, and the alignment of cultivated competencies with regional labour market needs. Thus, the economic dimension of vocational education quality transitions from formal resource control to strategic management of educational outcomes, where the priority is ensuring long-term socio-economic impact from educational activities.

The pedagogical demarcation of the quality concept concentrates on internal processes of professional personality development and the implementation of the competence approach. In this context, quality is a set of core competencies, rights, and responsibilities necessary for professional activity, as well as the alignment of learning goals and outcomes at the individual institutional level (Oliferuk, 2020). It encompasses the quality of applicants, scientific and pedagogical potential, the information-educational environment, and the management system. The internal quality assurance system holds particular significance, as it must include mechanisms for maintaining academic integrity, monitoring, and periodically reviewing educational programmes to update them according to labour market needs. Educational activity quality is therefore a dynamic category, constantly adjusted based on feedback from the production sphere and scientific research.

To deeply understand the structure of vocational education quality, it is expedient to consider the comparative characteristics of descriptors in the National Qualifications Framework (NQF) and the European Qualifications Framework (EQF), as they define the benchmarks for measuring learning outcome quality (Table 1.2).

The NQF surpasses its European counterpart in scope because, in addition to standard categories such as “knowledge”, “skills”, and “responsibility and autonomy”, it contains a “communication” descriptor, highlighting the importance of a specialist's capacity for social interaction and collaboration. This indicates the national system's orientation toward fostering holistic human capital, where socio-communicative skills are an integral component of professional quality. It is vital to emphasise that comparing the NQF and EQF has not only conceptual but also practical significance for ensuring vocational education quality, as descriptor alignment determines the opportunities for academic and professional mobility for learners. The European Qualifications Framework, built on the principle of learning outcomes, focuses on transparency and qualification comparability across EU countries,

while the NQF simultaneously serves as an internal regulator and a tool for harmonisation with the European education area (European Commission, 2023b).

Table 1.2. Comparison of Quality Descriptors in the NQF and EQF

Descriptors	EQF Interpretation	NQF Interpretation	Impact on Assessment
Knowledge	Theoretical and/or factual	Cognitive mastery of theory and practice	Fundamental qualification base
Skills	Cognitive and practical	Ability to apply knowledge to tasks	Operational readiness for work
Communication	(Included in other descriptors)	Capacity for interaction and data exchange	Social integration of the specialist
Responsibility and autonomy	Ability to act independently	Capacity for self-control and decision-making	Professional maturity and agency

The presence of the additional "communication" descriptor in the NQF strengthens the emphasis on social competence development, which is particularly crucial for modern vocational education where effective interaction, teamwork, and the ability to present results are key elements of professional success. In this context, the NQF structure demonstrates a drive toward a comprehensive assessment of vocational training quality, where technical, cognitive, and social components of professional competence are viewed as interconnected and equally important.

The consolidation of the competence paradigm in the vocational education system marked a transition from evaluating the volume of material taught to assessing the learner's actual achievements. Competence is viewed as a dynamic combination of knowledge, understanding, skills, abilities, values, and emotions that ensures the successful execution of tasks in real-life and professional situations. Unlike the traditional system oriented toward knowledge accumulation, competence-based learning directs learners toward working with information and mastering skills that make them competitive in the labour market (Grechyna, 2024). The role of the vocational educator in this model is transformed: they cease to be a mere transmitter of knowledge and become a facilitator of the process of independent skill mastery, which is critically important given the high intensity of technological change.

The transformation of human capital content in the digital age necessitates including new skill groups within learning outcomes: digital competencies, soft skills, and meta-skills. In an environment where routine tasks are automated, the value of empathy, leadership, teamwork, and critical thinking increases, as these qualities are the most difficult to

algorithmise. Human capital now includes the ability to work effectively in distributed teams and utilise digital platforms for collaboration in hybrid production processes. Thus, the quality of vocational education is evaluated by the degree to which a learner develops interdisciplinary thinking and the ethical use of technologies, specifically artificial intelligence. The modern paradigm of vocational education development is based on the concept of an educational ecosystem – a dynamic network of interconnected actors, resources, and technologies that ensure conditions for lifelong learning (Khomenko et al., 2023). The quality of such an ecosystem is defined by its integrity and capacity for synergy between the academic sector, business, and the state. Key components of a vocational institution's ecosystem include infrastructure (computer equipment, STEM labs), digital pedagogy (teacher competence), digital content, e-services, and transparent management based on qualitative data. Only through the harmonious development of all these elements is it possible to create a safe and effective digital environment that meets contemporary challenges.

Digitalisation acts not merely as a technical tool but as a leading organisational and pedagogical condition for improving vocational education quality. It enables the decentralisation of access to knowledge, ensuring equal opportunities for all citizens, and increases management efficiency through the use of big data for strategic decision-making. The digital transformation strategy for vocational colleges involves transitioning to paperless administration, utilizing systems like “Diia” and “Mriia”, integrating with the Unified State Electronic Database on Education (USEDE), and developing adaptive educational platforms (Guraliuk, 2023). A critical aspect is the quality of Educational Technology (EdTech) design (Foster et al., 2023): these must not only automate processes but also stimulate new teaching methodologies – personalised, authentic, and student-centred instruction. To systematise the factors determining the quality of the educational ecosystem in modern conditions, it is expedient to identify its key components and indicators (Table 1.3).

An indispensable vector for the development of the modern educational ecosystem is inclusivity, which guarantees access to high-quality vocational education for all students, including those with special educational needs. Digital technologies, such as artificial intelligence and augmented reality, create unique opportunities to adapt content to the individual physical, cognitive, or sensory characteristics of learners. The implementation of inclusive practices facilitates social integration and allows for the maximisation of society's human potential, preventing the “loss” of talent due to environmental accessibility barriers. The quality of inclusive learning in vocational education is determined not only by the presence of ramps but also by teachers' preparedness to work with assistive technologies and the creation of inclusive digital content.

The foresight (predictability) of vocational education quality becomes a critical success factor in conditions of uncertainty. It consists of the system's ability to anticipate

future labour market needs and prepare specialists whose skills will be relevant not only today but also in 5–10 years (Murashenko, 2024).

Table 1.3. Components and Indicators of College Educational Ecosystem Quality

Ecosystem Component	Key Quality Indicators	Expected Human Capital Impact
Infrastructural	Availability of STEM labs, high-speed Internet	Technological literacy, resource access
Pedagogical	Level of teachers' digital and soft skills	High teaching quality, innovative methods
Content-related	Adaptability of programmes, micro-qualifications	Knowledge relevance, learning flexibility
Socio-inclusive	Barrier-free access, use of assistive IT	Equal access, social justice
Data-driven Management	Use of Big Data, administrative transparency	Evidence-based decisions, debureaucratisation

The predictive quality model in vocational institutions is based on analysing technological development trends and fostering students' readiness for constant knowledge renewal. This requires high proactivity and mobility from teachers, along with the ability to model pedagogical processes considering probable future scenarios. Thus, foresight becomes a management principle where quality is evaluated not by compliance with past models but by the graduate's capacity for successful life activity amidst post-war recovery and global transformations (National Agency of Ukraine on Civil Service, 2023).

Expanding on the institutional conditions for ensuring vocational education quality, emphasis should be placed on the transition from purely academic criteria toward professionally-oriented tools for verifying professional qualifications. Modern occupational standards serve as the foundation for developing high-quality vocational education programmes. As of early 2024, the development of next-generation occupational standards has become a continuous process, facilitating rapid adjustments to training content (Ministry of Education and Science of Ukraine, 2023a). This ensures the validity of educational outcomes: information obtained during the analysis of learning task performance must contain reliable data for predicting future professional success. The use of occupational standards enables a transition toward assessment based on specific labour functions, making graduate training quality as close as possible to industrial realities. Independent assessment of professional qualifications acts as a tool for external quality confirmation, neutralising the subjectivity of the vocational institution. The implementation of professional qualifications awarded by accredited qualification centres allows for the recognition of skills acquired

through non-formal and informal education. Qualification centres conduct learning outcome assessments following established procedures. These encompass theoretical and practical testing, ensuring the issuance of certificates recognised on the national labour market. The National Qualifications Agency plays a vital role in this process as a tripartite body, acting as a guarantor of transparency and procedural compliance with state requirements.

European integration is a powerful stimulus for modernising vocational education quality assurance systems in Ukraine. The Copenhagen Process, initiated in 2002, became the foundation for strengthening European cooperation in vocational education and training, promoting transparency and mutual recognition of qualifications. The evolution from the Copenhagen (Council of the European Union, 2020b) to the recently adopted Herning Declaration 2026–2030 demonstrates a shift in emphasis toward digital and green transformation, social inclusion, and increasing the attractiveness of vocational education. The Herning Declaration defines vocational education as the engine of Europe's future competitiveness, highlighting the need for measurable learning outcomes and strengthened educational system accountability. The declaration emphasises that vocational education should not be a "secondary choice" compared to higher education but should become a modern sector preparing specialists for a high-tech economy (Council of the European Union, 2025). In this context, the shift toward "VET-S" policies (vocational education and skills development) reflects the broader needs of the adult population for continuous retraining and upskilling throughout their careers. Ukraine, possessing a stable National Qualifications Framework aligned with the European Qualifications Framework, demonstrates readiness for the fair and transparent recognition of qualifications, which is critical for the cross-border careers of specialists. Accordingly, centres of vocational excellence are becoming network structures to support national reforms based on best practice exchange, innovation implementation, and close cooperation with the business environment (Radkevych, 2025b).

In summary, it can be asserted that vocational education quality in modern conditions is an integral category combining the economic expediency of human capital investment with the pedagogical effectiveness of the competence approach. The evolution from static knowledge to dynamic competencies, the development of digital and inclusive educational ecosystems, and the orientation toward occupational standards and independent assessment are the strategic vectors defining the viability of the educational system. The transformation of human capital in the digital era requires not only new technical solutions but also a change in the very philosophy of vocational education quality: it must be proactive, oriented toward the needs of the individual, and capable of ensuring the sustainable development of society amidst global challenges. The establishment of such a quality model is a guarantor of economic security and social progress, where vocational education becomes the true foundation for forming the nation's intellectual and professional potential.

1.2. EUROPEAN QUALITY ASSURANCE POLICY FRAMEWORKS FOR VET AND SHORT-CYCLE TERTIARY EDUCATION: IMPLEMENTATION POTENTIAL FOR UKRAINIAN AGRICULTURAL COLLEGES

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This chapter analyses European quality assurance policy frameworks relevant to vocational education and training and short-cycle tertiary education and examines their implementation potential for Ukrainian agricultural colleges delivering professional pre-higher education. Using a normative–analytical approach, it synthesises expectations embedded in the Standards and Guidelines for Quality Assurance in the European Higher Education Area and the European Quality Assurance Reference Framework for vocational education and training and relates them to Ukrainian legal requirements for internal and external quality assurance systems. The chapter clarifies the positioning of professional pre-higher education at the interface of vocational education and training and short-cycle tertiary education and substantiates the use of both quality assurance points. The main result is a set of policy-informed principles for assuring the quality of educational activities (process dimension) as the key determinant of professional training outcomes (result dimension) for professional junior bachelors. These principles are mapped onto a methodological quality assurance system that integrates goals, content, forms and methods, assessment/control, and pedagogical interaction, and supports evidence-informed continuous improvement aligned with labour-market expectations in the agricultural sector.

Keywords: *professional pre-higher education, internal quality assurance, quality culture, learning-outcomes, transparency.*

Ensuring the quality of professional training in Ukrainian agricultural colleges has become a strategic imperative in conditions of economic restructuring, labour-market volatility, and post-crisis transformation of education. National legislation defines quality assurance (quality assurance) not as an episodic control procedure but as a shared responsibility of the state, external quality bodies, and education providers, including the establishment and functioning of internal quality assurance systems (Verkhovna Rada of Ukraine, 2019c, Art. 17). For agricultural colleges, the quality agenda is sharpened by the need to demonstrate compliance with standards while responding to competence demands in the agricultural and food industry sectors.

In comparative European terms, Ukraine's professional pre-higher education (фахова передвища освіта) occupies the interface between vocational education and

training (VET) and short-cycle tertiary education. While Ukrainian law treats it as a distinct level with mandatory internal QA and regulated external procedures (Verkhovna Rada of Ukraine, 2017a, Art. 16; Verkhovna Rada of Ukraine, 2019b, Art. 17), the closest cross-national classifier is ISCED level 5 (short-cycle tertiary), typically practice-oriented and occupationally specific, with possible progression to bachelor studies (UNESCO, 2012, p. 49). This positioning substantiates the parallel use of two European normative QA reference sets: the ESG as a general reference for institutional QA policies and processes (European Association for Quality Assurance in Higher Education et al., 2015, p. 12) and EQAVET as a VET-oriented reference grounded in a continuous improvement cycle (European Commission, 2009).

Recent research increasingly shifts QA discourse from compliance to quality culture and evidence-informed improvement. Comparative analyses show how QA reforms are operationalised through transparency, monitoring routines, and institutional learning, while also revealing governance tensions in implementation (Kohoutek et al., 2025, p. 755). Studies on quality culture demonstrate that formal QA structures are effective only when they interact with everyday academic practices (Nygren-Landgärds et al., 2024, pp. 51–52). Ukrainian research emphasises QA as a lever of sustainable development and European integration, focusing on trust, transparency and stakeholder feedback (Stukalo & Lytvyn, 2021, pp. 11–12) and consolidating QA terminology in the European-integration dimension (Yeremenko et al., 2024). Domestic scholarly discourse increasingly interprets quality assurance as a multi-dimensional task that requires coherent national and institutional "quality profiles" and comparability with European reference points (Lugovyi et al., 2019, p. 4). In parallel, quality development in vocational and professional pre-higher education is conceptualised through a systemic and policy-oriented lens, emphasising the institutional architecture of quality, responsibility distribution, and the role of methodological support in sustaining learning outcomes (e.g., Radkevych, 2025, p. 5). Considering this background, the chapter systematises European and Ukrainian regulatory reference points and derives policy-informed principles that can guide the design of a methodological system for quality assurance of the educational process in agricultural colleges.

Agricultural colleges operate at the intersection of education and production: extensive practice components, seasonal work cycles, and rapidly changing agrotechnologies make the alignment of curricula, assessment and workplace learning a permanent QA challenge. At the same time, the sector's sustainability agenda increases demand for competence profiles that combine technical, digital and environmental dimensions, which must be reflected in learning outcomes and monitored through valid evidence.

In this research, the quality of professional training in agricultural colleges is interpreted as a multidimensional characteristic of educational outcomes that reflects the degree graduates' professional competences correspond to in the aspects of professional pre-higher education standards and labour-market demands. The degree is ensured through the functional interaction of methodological components and continuous, objective monitoring of learners' achievements. Building on Ukrainian legislation, QA is treated as a system combining internal QA system at provider level and external QA system through authorised procedures and bodies (Verkhovna Rada of Ukraine, 2019b, Art. 17).

Conceptually, it is necessary to consider and distinguish two phenomena: QA policy from QA technology realized in a college. QA policy is a strategic governance framework that articulates values, goals, roles and responsibilities, stakeholder engagement, evidence requirements, and mechanisms for transparency and continuous improvement. QA technology is the implementation of policy in the educational process of a college through procedures, methods, instruments, and feedback loops that translate policy commitments into programme delivery and achievement of learning outcomes. In the analytical framework, external QA provides macro-level requirements, internal QA acts as the institutional system aligning strategy and evidence, and implementation is anchored through a methodological system integrating goals, content, forms and methods, assessment/control, and pedagogical interaction. This methodological system is the key mechanism through which QA policy becomes observable in processes and outcomes.

The distinction is analytically useful because it prevents the common reduction of QA to documentation: policy defines the institutional "rules of the game", whereas technology specifies how those rules are enacted in teaching, learning, assessment and feedback. For professional pre-higher education, this translation is especially important because programmes must simultaneously meet legal QA requirements and remain flexible enough to respond to employer expectations and changes in occupational standards.

European QA reference points converge around learning-outcomes orientation, transparency and accountability, stakeholder involvement, and continuous improvement supported by evidence. The Standards and Guidelines for Quality Assurance in the European Higher Education Area (ESG) require institutions to maintain a public QA policy embedded in strategic management and implemented through appropriate structures with stakeholder participation; they also emphasise public information, information management, and ongoing monitoring and periodic review of programmes (European Association for Quality Assurance in Higher Education et al., 2015, pp. 26–28). The European Quality Assurance Reference Framework for vocational education and training (EQAVET, (integrated into the 2020 Council Recommendation on VET) logic

complements this by emphasising cyclic quality management and the use of descriptors and indicators for evaluation and improvement (Council of the European Union, 2020a, pp. 6, 11–13). Together, these reference points provide a coherent language for policy design (what must be ensured) and for managerial instrumentation (how evidence is collected and used), which is essential when professional pre-higher education is positioned between vocational and tertiary logics. For agricultural colleges, these principles are transferable because they can be translated into internal QA routines and teaching-and-learning management: learning outcomes link process quality to competence achievement; transparency supports open procedures and accessible evidence; and cyclical review normalises improvement as routine rather than inspection.

In practical terms, implementation potential depends on the availability of institutional capacities to manage QA information and to sustain stakeholder communication. Moreover, it strengthens the European emphasis on stakeholder participation by recommending governance partnerships that involve social partners and other relevant stakeholders (European Commission, 2023a, p. 22). The research on stakeholder engagement shows that advisory formats can strengthen the relevance of programme outcomes and support shared responsibility for improvements (Attree, 2025, pp. 76–78). For Ukrainian agricultural colleges, such engagement is particularly valuable for calibrating work-based learning tasks, validating competence achievement in authentic settings, and updating programme content in response to technological and regulatory changes in the sector.

Under the Law of Ukraine On the Professional Pre-higher Education, the internal quality assurance system must ensure both the quality of educational activities and the quality of professional pre-higher education provision (Verkhovna Rada of Ukraine, 2019b, Art. 17(1)(1)). The Law On Education defines the quality of educational activity as the level of organisation, provision and implementation of the educational process that ensures high-quality education and meets legal and/or contractual requirements (Verkhovna Rada of Ukraine, 2017a, Art. 1(30)). Accordingly, this study positions its niche in the quality of educational activities (process dimension) as the determinant of the quality of professional training outcomes (result dimension), and focuses on methodological operationalisation of internal QA in the educational process.

European QA policy frameworks operationalise “quality” through a relatively stable set of standards and principles that make institutional QA policies implementable and auditable. The following analytical block identifies policy “pillars” that are most directly convertible into operational instruments and routines. The intent was to extract those requirements that can be embedded into a methodological QA system and used as design constraints for educational-process modernisation.

European QA frameworks operationalise quality through standards that support implementation and auditability. Student-centredness requires teaching and assessment to enable active learning and the continuous adjustment of teaching practices based on evaluation (European Association for Quality Assurance in Higher Education et al., 2015, p. 12). Learning-outcomes orientation is embedded in programme design and approval, ensuring that objectives and outcomes are explicit and aligned with qualifications frameworks (European Association for Quality Assurance in Higher Education et al., 2015, p. 8). Programme coherence is ensured through systematic design and internal consistency between objectives, workload, learning environments (including placements), and assessment rules known in advance (European Association for Quality Assurance in Higher Education et al., pp. 11–12). Transparency is supported by the expectation that institutions publish clear, accurate, objective, up-to-date and accessible information about programmes and activities (European Association for Quality Assurance in Higher Education et al., 2015, p. 13). For practice-oriented programmes, transparency also includes clear communication of workplace learning requirements, assessment rubrics, and complaint/appeal procedures so that students and mentors share the same expectations. These standards set the minimum architecture of a QA policy that can be translated into methodological arrangements and evidenced through monitoring and follow-up improvement.

For agricultural colleges in Ukraine, student-centredness also implies structured support for heterogeneous learners and safe participation in workplace learning, including clear guidance on assessment criteria in real production settings. Learning-outcomes orientation is strengthened when outcomes are translated into observable performance indicators for both classroom and workplace tasks, enabling consistent assessment across teachers and mentors. Programme coherence further requires that work-based learning is not treated as a separate block but is integrated with theoretical modules through shared outcomes and aligned assessment tools.

Governance arrangements define how QA commitments become routine decisions. A public QA policy must be supported by clear structures and processes, developed and implemented with stakeholder participation. Leadership sets priorities and provides resources; designated QA units coordinate reviews and evidence management; programme teams and teachers implement QA through curriculum design and assessment; and decisions are expected to be cyclical, evidence-informed and followed by documented improvements (European Association for Quality Assurance in Higher Education et al., 2015, p. 25).

A key governance implication is that QA responsibility should be distributed but coordinated: decentralised ownership at programme level is necessary for meaningful change, yet central coordination is required to ensure comparability of indicators and

consistency of decisions (Council of the European Union, 2020a, pp. 15–16). This coordination also supports integrity management (preventing plagiarism, ensuring fair grading and reliable workplace assessment), which directly affects the credibility of monitoring data and the legitimacy of improvement actions. For agricultural colleges, governance must also secure academic integrity as a condition of trustworthy evidence and fair assessment, while structured involvement of employers, graduates and students strengthens competence relevance and the legitimacy of QA decisions (Verkhovna Rada of Ukraine, 2019b, Art. 17).

Operationally, responsibility distribution should be reflected in formal decision cycles (annual programme review, mid-cycle monitoring, and extraordinary reviews triggered by risk signals such as low achievement, negative feedback or integrity violations). Stakeholder engagement is most productive when institutionalised through predictable formats, such as advisory boards, structured consultations on learning outcomes, co-design of workplace assignments, and participation in graduate tracking. So that external feedback becomes comparable evidence rather than anecdotal opinion.

An evidence base makes QA decisions verifiable and improvement-oriented. Institutions are expected to manage and use information for effective programme management, enabling monitoring, evaluation and enhancement (European Association for Quality Assurance in Higher Education et al., 2015, p. 14). EQAVET logic reinforces monitoring through common reference indicators and descriptors used for evaluation and review (Council of the European Union, 2020a, pp. 11–13). For Ukrainian agricultural colleges, the evidence architecture should combine outcome-based indicators (assessment mapped to learning outcomes, progression and completion, performance in work-based learning) with feedback instruments (surveys/interviews with students, graduates and employers; focus groups with teachers and mentors) and documentation of follow-up actions.

Data governance matters for usability: sources, definitions, and collection frequency should be fixed, and access rules should respect confidentiality while enabling analysis for improvement. A practical balance is to publish aggregated results for transparency and to keep individual-level data restricted to authorised staff, with clear procedures for using evidence in programme review. A balanced data model is essential: quantitative data support trend detection, while qualitative evidence explains mechanisms and contextual factors, strengthening conclusions about outcome quality and targeting improvements.

To ensure interpretability, indicator sets should be limited to a manageable core (e.g., achievement of key learning outcomes, pass rates in competence-critical modules, completion of workplace tasks, and employer satisfaction) and complemented by qualitative explanations captured through reflective reports, peer review of assessment

tools, and structured analysis of student experience. Evidence quality depends on the validity of assessment instruments and on integrity safeguards, which protect monitoring data from distortion and make comparisons over time meaningful.

Continuous improvement is the mechanism that keeps QA operational. Within the EQAVET approach, quality management is organised as a recurring cycle of Planning–Implementation–Evaluation–Review, which mirrors the Plan–Do–Check–Act (PDCA) logic and connects goals, actions, evidence, and corrective decisions (Council of the European Union, 2020a, p. 12). The ESG embed the same rationale in requirements for ongoing monitoring and periodic review leading to documented enhancements communicated to stakeholders (European Association for Quality Assurance in Higher Education et al., 2015, p. 15). For the current research, the improvement cycle is also relevant as requires decision traceability: documented evidence, assigned responsibilities, deadlines and follow-up verification.

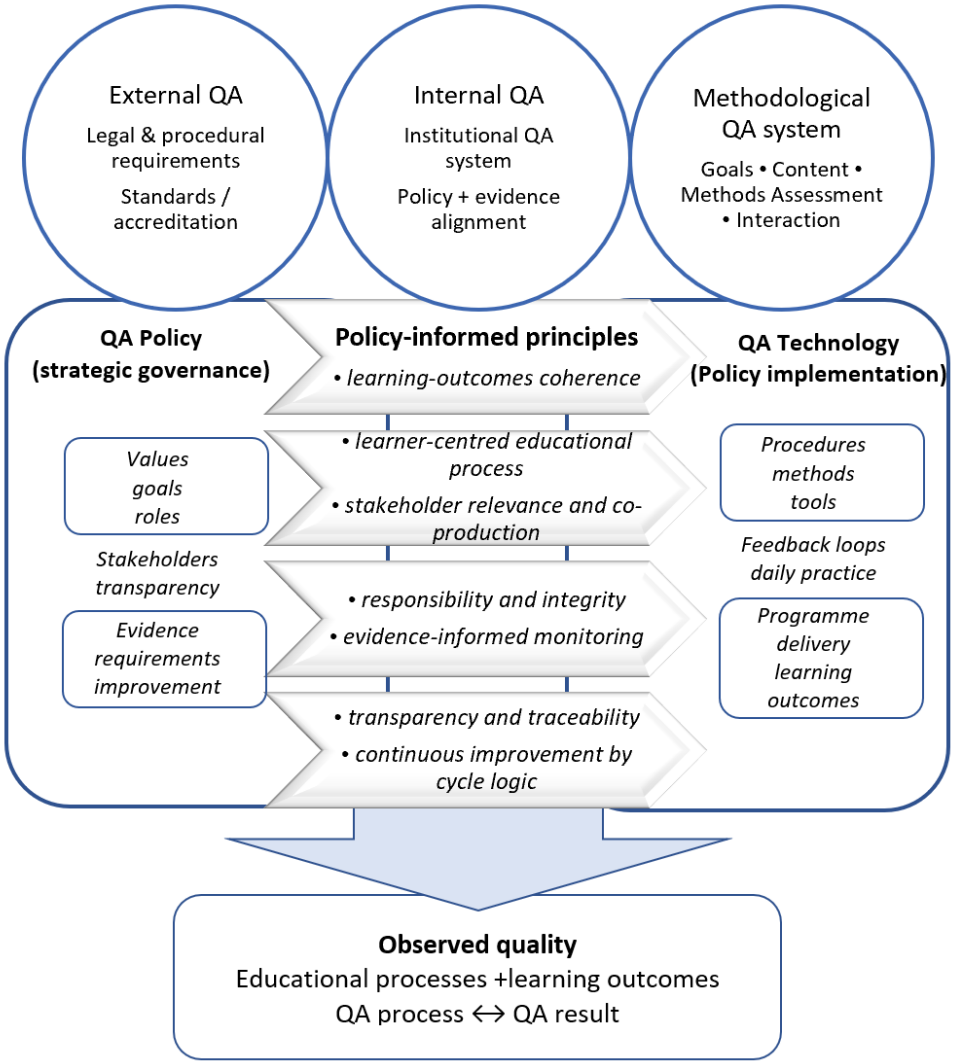
The analysed policy pillars translate into QA technology when strategic commitments are expressed as operational rules for the educational process on the basis of the following principles: (1) learning-outcomes coherence (educational activities are designed and reviewed against intended learning outcomes and competence profiles aligned with standards and labour-market expectations); (2) learner-centred educational process (teaching, learning and assessment practices are organised to support active learning pathways and fair, transparent assessment); (3) stakeholder relevance and co-production (employers, students and graduates are systematically involved in defining relevance, validating outcomes (including workplace learning) and reviewing programme improvement actions); (4) responsibility and integrity (roles, decision rights and integrity safeguards are explicit, ensuring trustworthy assessment and reliable evidence for QA decisions); (5) evidence-informed monitoring (decisions on educational activities rely on a balanced evidence base combining indicators and qualitative feedback mapped to learning outcomes); (6) transparency and traceability (key QA procedures, criteria and results are communicated openly and decisions are documented with follow-up verification); and finally (7) continuous improvement by cycle logic (educational activities are improved through a recurring cycle of planning, implementation, evaluation and review, with corrective actions and re-measurement of effects).

Standards become design rules for curricula, tasks and assessment; governance is expressed in role allocation among leadership, QA coordinators, programme teams, teachers and workplace mentors; evidence requirements become a defined set of indicators and feedback tools linked to review decisions; and the improvement cycle supplies a PDCA sequence that makes actions time-bound and verifiable. A QA technology can therefore be described as an algorithm comprising planning learning outcomes and competence profiles; designing coherent content and learning

environments (including work-based components); implementing teaching, learning and assessment with agreed criteria and integrity safeguards; monitoring achievement of outcomes through indicators and feedback; and reviewing and improving programmes through documented follow-up and re-measurement (Figure 1.1).

At the same time, the technology should specify minimal documentation artefacts that support traceability without creating excessive bureaucracy: an outcomes map, an assessment blueprint, a monitoring dashboard, and an improvement log linked to responsible actors and deadlines. Embedding these artefacts into the PDCA cycle enables a coherent sequence from planning decisions to evidence collection and corrective action.

Figure 1.1. Conceptual model linking QA policy and QA technology across governance levels based on policy-informed principles



Within the methodological system, technologisation can be expressed as coordinated redesign actions: goals are specified as outcome statements and competence descriptors; content is updated through curriculum mapping and integration of sustainability-relevant topics; forms and methods are diversified through practice-oriented learning and simulation aligned with real agricultural processes; assessment/control is redesigned through criteria-based tools and outcome mapping; and pedagogical interaction is strengthened through mentoring and feedback practices. Such coordinated changes ensure a systemic effect and reduce the risk that QA remains fragmented across documents and units.

In this model, the methodological system of QA of the educational process is the main operational mechanism. It integrates subsystems of goals, content, forms and methods, assessment/control, and pedagogical interaction. The proposed QA technology aims at systemic and comprehensive modernisation across all methodological components, strengthening the quality of professional training in Ukrainian agricultural colleges. Alignment with the agricultural labour market is supported through formalised stakeholder channels, competence validation in workplace learning, and iterative updating of programme content and assessment tools based on monitoring results. The proposed configuration is scalable: it can be adapted to different programme profiles and institutional capacities without losing comparability of core indicators.

The analysed principles demonstrate that European QA approaches are most productive for agricultural colleges when they are interpreted not as external templates but as governance logic that connects policy, evidence, and improvement. Their key value lies in shifting quality assurance from episodic control to a routine institutional practice based on explicit responsibilities, transparent communication, and decision traceability supported by data. These approaches also strengthen the link between the process quality of educational activities and the outcome quality of professional training, making learning outcomes and competence achievement the core reference point for management and pedagogy. As a result, they provide a coherent foundation for constructing a QA technology that modernises the methodological system across its subsystems and aligns programme delivery with labour-market expectations. The next research stage will focus on developing and validating practical instruments, such as indicators, monitoring tools, feedback procedures, and decision protocols which are suitable for implementation in Ukrainian agricultural colleges.

1.3. QUALITY ASSURANCE SYSTEMS IN VOCATIONAL EDUCATION AND TRAINING: A COMPARATIVE ANALYSIS OF THE EXPERIENCES OF THE KINGDOM OF THE NETHERLANDS AND UKRAINE

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This chapter presents a comparative analysis of the quality assurance systems within vocational education and training in the Kingdom of the Netherlands and Ukraine. It examines the distinctive features of the Dutch model, which relies on risk-based inspectorate supervision, substantial institutional autonomy for colleges, and the strategic integration of industry stakeholders through the Foundation for Cooperation on Vocational Education, Training and the Labour Market. The analysis further explores the transformation of the Ukrainian educational landscape through the implementation of European Quality Assurance in Vocational Education and Training standards and adaptation to contemporary crisis-related challenges. The study identifies specific points of convergence between both systems, particularly regarding internal monitoring mechanisms and the assessment of learning outcomes. Furthermore, the research delineates strategic benchmarks for adapting the Dutch experience to modernise the national system – specifically by fostering a culture of self-assessment and strengthening sectoral partnerships. Such measures serve as a critical instrument for enhancing graduate competitiveness and ensuring the sustainable post-war recovery of Ukraine's national economy.

Keywords: *vocational education and training (VET), Kingdom of the Netherlands, Ukraine, comparative analysis, EQAVET standards, quality of education*

The contemporary paradigm of vocational education and training (VET) in a globalised world is undergoing fundamental transformations, driven by the necessity to adapt human capital to rapid technological shifts, digitalisation, and the requirements of the "green" transition. In this context, quality assurance (QA) systems emerge not merely as control mechanisms but as strategic instruments to guarantee the competitiveness of national economies and the social resilience of society. The theoretical origins of the quality assurance concept within the European Education Area are inextricably linked to the development and implementation of the European Quality Assurance Reference Framework for Vocational Education and Training (EQAVET), which was formally established by the Recommendation of the European Parliament and of the Council in 2009 (European Commission, 2026a). EQAVET provides EU Member States and partner countries with a flexible toolkit based on a cycle of continuous quality improvement,

comprising four interconnected phases: planning, implementation, evaluation, and review (European Commission, 2026b). This cycle, known as the PDCA model, enables educational providers and systemic regulators not only to record current results but also to identify areas for improvement systematically, building upon an evidence base and the engagement of a wide range of stakeholders. Strengthening a culture of quality within the EQAVET framework also necessitates a transition from quantitative indicators toward a qualitative assessment of education's impact on individual life trajectories and community development. The implementation of this framework requires the creation of robust feedback mechanisms where each PDCA cycle concludes not merely with a report, but with tangible management decisions aimed at modernising infrastructure, updating learning content, and enhancing the professional development of teaching staff. In the modern environment, where knowledge becomes obsolete faster than a full training cycle can be completed, the systematic nature and predictability of quality assurance processes ensure that state and business investments in VET yield the expected socio-economic effects. Consequently, EQAVET serves not only as a technical instruction but as a philosophical foundation for constructing a lifelong learning ecosystem where quality is a shared responsibility of all participants in the educational process, ultimately determining a nation's ability to prosper amidst future uncertainty.

The 2020 EU Council Recommendation on VET for competitiveness, social fairness, and resilience significantly expanded the horizons of EQAVET by integrating quality requirements not only for initial VET (IVET) but also for continuing vocational education and training (CVET) (European Commission, 2026a). The updated framework emphasises learning outcomes, the flexibility of educational pathways, the digital readiness of systems, and the role of teachers and trainers as key agents of quality. To monitor the effectiveness of VET systems at the pan-European level, ten key indicators have been identified, including: the relevance of quality assurance systems, investment in teacher training, participation rates in VET programmes, completion rates, graduate employment rates, the utilisation of acquired skills in the workplace, unemployment rates, the inclusion of vulnerable groups, mechanisms for identifying labour market needs, and schemes to ensure access to training. Each of these indicators serves as a marker of how effectively the educational system fulfills its social and economic mission by facilitating the transition from learning to stable employment (Evangelista et al., n.d.).

The Kingdom of the Netherlands demonstrates one of Europe’s most sophisticated VET models, characterised by a high degree of institutional autonomy and deep integration with the labour market. The Dutch system of secondary vocational education (MBO) is based on the Adult and Vocational Education Act (WEB), which grants colleges (ROCs, AOCs) significant freedom in resource management and curriculum development, provided they adhere to national occupational standards. A key feature of

the Dutch approach is risk-based supervision conducted by the Inspectorate of Education. In contrast to traditional models of total control, the Dutch Inspectorate focuses its attention on institutions showing signs of declining quality or financial instability, while successful institutions receive more space for innovation and self-regulation (Eurydice, 2023). This approach stimulates the development of an internal "quality culture", where responsibility for the final outcome is shared among institutional leadership, teaching staff, and social partners (Inspectorate of Education, 2024).

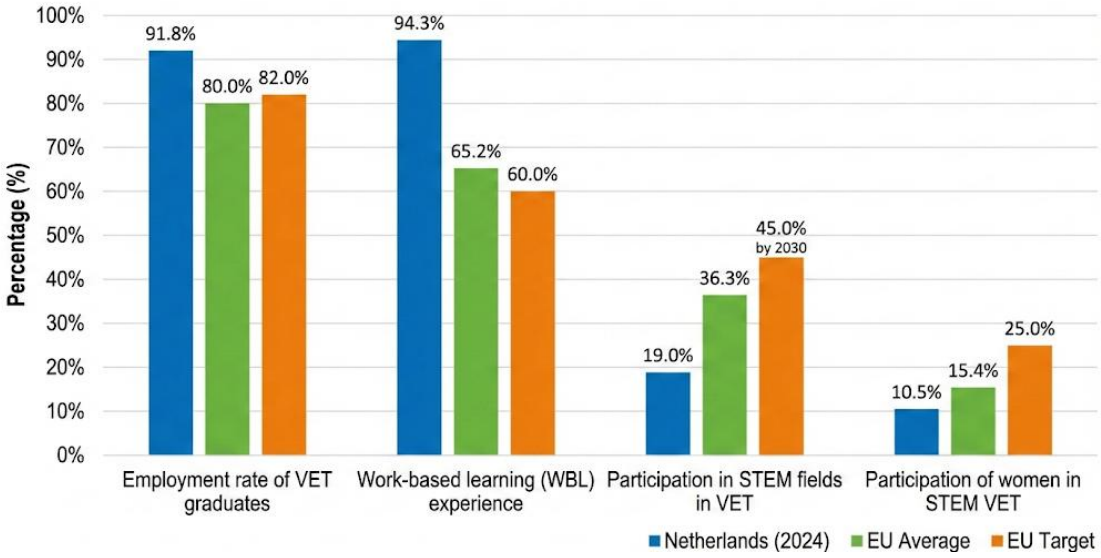
A vital component of the Dutch model's resilience is the activity of the Foundation for Cooperation on VET and the Labour Market (SBB), which acts as a mediator between educational institutions and industry representatives. Within the SBB framework, occupational standards are developed and constantly updated, allowing for the rapid integration of new digital and "green" skills into the educational process. The oversight system by the Inspectorate of Education subsequently transforms into a multi-level verification of not only learning outcomes but also the effectiveness of process management. The Inspectorate applies a differentiated methodology: institutions consistently demonstrating high quality (rated "satisfactory" or "good" on the national scale) are exempt from intensive inspections, allowing them to focus on experimental pedagogical methods and strategic partnerships. Such a mechanism creates a powerful incentive for self-improvement, transforming quality from an external requirement into an internal value of the educational community, where monitoring graduate success and their subsequent professional trajectories becomes a key evidence-based indicator of success (Inspectorate of Education, 2024).

The organisation of work-based learning (WBL) occupies a special place in the quality assurance architecture, implemented through two primary pathways: the school-based pathway with an internship (BOL) and the dual pathway based on employment (BBL). In both cases, the quality of vocational training is guaranteed through a rigorous accreditation procedure for partner companies conducted by the SBB. Every enterprise hosting a learner must meet established standards regarding safety, the availability of qualified mentors, and the alignment of work tasks with the programme's learning objectives. This integration into the real economic sector allows Dutch colleges to minimise the gap between classroom theory and workplace practice. Simultaneously, internal quality assurance systems in colleges are based on EQAVET principles, where gathering feedback from learners and employers is a mandatory element of the improvement cycle. The use of Big Data to analyse dropout rates and study duration enables institutions to implement proactive support measures for learners, thereby increasing the overall social inclusivity of the VET system (Eurydice, 2023). Furthermore, the current stage of Dutch VET development is characterised by increased attention to the "Lifelong Learning" concept, which necessitates greater flexibility from

quality assurance systems and the ability to evaluate non-formal and informal learning outcomes. Validation of Prior Learning (VPL) is becoming an integral part of the strategy to enhance human capital mobility, allowing adult workers to certify their competencies and obtain relevant certificates without the need for a full repeat course of study. This creates an adaptive educational environment where quality is measured not only by diplomas but by an individual's capacity to continuously update their professional profile amidst rapid technological change.

The effectiveness of the Dutch model is confirmed by statistical data (Figure 1.2): the employment rate of VET graduates in 2024 was 91.8%, significantly exceeding the European average (80.0%) and the EU target for 2025 (82.0%) (European Commission, 2025a).

Figure. 1.2. Comparative Characteristics of VET System Indicators in the Netherlands and the EU



Nearly all VET students in the Netherlands (94.3%) gain work-based learning experience during their studies, resulting from the coordinated work of the SBB Foundation; this body plays a critical role in the quality assurance system by taking responsibility for the accreditation of over 250,000 companies where students can undertake internships or apprenticeships, as well as for developing and updating occupational standards across nine economic sectors (Cedefop, 2023b). This ensures that VET content always corresponds to current business demands and that practical training occurs in a safe, professional environment under the supervision of certified mentors. Simultaneously, the Dutch system faces new challenges reflected in the annual "State of Education" reports for 2023 and 2024. The Inspectorate notes a worrying trend toward

declining basic skills literacy and numeracy among vocational college students, which potentially hinders their further education and successful socialisation. Moreover, a significant labour shortage persists in STEM fields: only 19% of students choose scientific and technical pathways, which is substantially lower than the EU average of 36.3% (Inspectorate of Education, 2023). In response to these challenges, the Dutch government, together with social partners, signed the "VET Working Programme 2023–2027", which aims to improve the quality of basic skills, ensure equal opportunities for vulnerable student groups, enhance youth mental health, and stimulate interest in professions related to the energy transition and digitalisation (European Commission, 2025a).

Ukraine, having chosen the path of European integration, is conducting a large-scale modernisation of its national VET system, aligning with EQAVET standards and adapting to the extreme conditions of martial law. The Strategic Plan of the Ministry of Education and Science of Ukraine until 2027 and the new Law "On Vocational Education" (No. 4574-IX), adopted in 2025, identify educational quality as a key priority to ensure national recovery and human capital development (Eurydice, 2025b). The reform envisages a transition to a decentralised management model where significant powers are transferred to regional and institutional levels, allowing institutions to respond more flexibly to local labour market needs and the requirements of internally displaced persons (Leu-Severynenko, 2025). The introduction of institutional audits as a form of external quality assurance, conducted by the State Service of Education Quality of Ukraine (SSEQU), is designed to evaluate not only learning outcomes but also the management and educational processes within institutions. The implementation of institutional audits in the Ukrainian context serves as the foundation for building internal quality assurance systems which, according to updated legislation, must be implemented in every vocational education institution. This process involves not only monitoring curricula but also creating an inclusive educational environment, digitalising management processes, and developing public-private partnerships. A vital component of this transformation is the establishment of Centres of Professional Excellence (CoPEs), which function as innovation hubs where best quality assurance practices are refined, new occupational standards are tested, and vocational educators undergo professional development in collaboration with leading employers. The application of self-assessment methodology, correlating with the PDCA (Plan-Do-Check-Act) cycle, allows Ukrainian colleges and lyceums to transition from a model of passive compliance with state directives to a model of active strategic planning; this shift is critical under limited resources and the need for rapid workforce training to rebuild destroyed infrastructure (Leu-Severynenko, 2025). Orientation toward EQAVET indicators, such as graduate satisfaction levels and the proportion of those employed in their specialisation, enables

the construction of a transparent accountability system for society and donors supporting the reform (Radkevych, 2025b).

Parallel to this, the Dutch experience in addressing the basic skills deficit and stimulating STEM education serves as a valuable guide for Ukrainian reformers, as similar problems are intensifying in Ukraine due to educational losses caused by the war and remote learning formats. The VET Working Programme 2023–2027 in the Netherlands places a particular emphasis on "regional quality agreements", where educational institutions, municipalities, and businesses jointly invest in developing the competencies required for local economic growth. In Ukraine, this approach is reflected in the creation of sectoral councils and the involvement of employers in curriculum development based on a competency-based approach, which aligns with the National Qualifications Framework harmonised with the European Qualifications Framework (EQF). A significant innovation is the implementation of the dual form of education, where training quality is guaranteed through joint control by the educational institution and the enterprise, minimising the risks of graduate skills mismatching modern technological requirements. Consequently, both countries, despite different starting conditions and challenges, are moving toward creating flexible, human-centric VET systems where quality is not a static indicator but a dynamic process of continuous improvement oriented toward future global labour market needs. Specific attention in harmonising the Ukrainian vocational education system with European standards is devoted to the digitalisation of quality assurance procedures and data collection. The implementation of an Education Management Information System (EMIS) allows for the real-time monitoring of learner educational trajectories, which is a key condition for evidence-based policy. This correlates with the Dutch practice of risk-based supervision, as it enables regulators to identify institutions requiring additional support before crisis situations arise. Combined with an emphasis on the "green" transition, which involves integrating environmental competencies into all occupational standards, the Ukrainian vocational education system is transforming into a driver of sustainable development. According to national reforms in vocational education until 2026, the priority remains not only expanding access to education for vulnerable categories but also ensuring the high quality of this education, as confirmed by internationally recognised certificates and a high level of trust from the international community (Eurydice, 2025b). This creates conditions for Ukraine's full integration into the European Education Area, where vocational education is viewed as the foundation for innovative breakthroughs and social cohesion. The 2024 SSEQU analysis (Table 1.4) revealed several systemic problems requiring urgent resolution: the misalignment of programme content with occupational standards, a funding deficit for modernising Vocational Training Centres (VTCs), and the incomplete transfer of institutions from state to communal ownership (Kravets, 2025b).

Table 1.4. Key Challenges in the Development of the Ukrainian Vocational Education System and Responding Entities

Challenges in the Ukrainian VET system (2024)	Description and consequences	Responding Entity
Suboptimal institutional network	Presence of small-scale institutions with low resource efficiency	MES, Regional Administrations, Tripartite Councils
Labour market mismatch	Training for occupations without regional demand; shortages in critical sectors	Employers, Regional Councils
Outdated facilities and programmes	Learning content fails to meet occupational standards and modern technologies	VTCs, Centres of Excellence
Shortage of teaching staff	Lack of practical trainers with modern industrial experience	VET institutions, Business partners
Disruptions in distance education	Difficulty in ensuring quality of practical skills in online mode during crises	SSEQU (State Service of Education Quality)

The new Law of Ukraine "On Vocational Education" introduces innovative partnership mechanisms, such as Supervisory Boards, which include employers and founders on a parity basis (Leu-Severynenko, 2025). These boards are granted the right to influence the development strategy of the educational institution, approve financial plans, and initiate audits, effectively transforming the role of business from a passive consumer of labour into an active participant in the educational process. Another important step is the development of qualification centres that conduct independent assessment and recognition of non-formal and informal learning outcomes, which is critical for the rapid retraining of the adult population during wartime. A comparative analysis of the experiences of the Netherlands and Ukraine facilitates the identification of convergence points and specific discrepancies in quality assurance approaches. Both countries are implementing the "Centres of Professional Excellence" model as innovation hubs uniting education, science, and business to solve complex economic tasks. There is also a shared interest in the digitalisation of quality assurance processes: in the Netherlands, this is realised through the "Npuls" programme and the implementation of micro-credentials; in Ukraine, it occurs through the creation of digital educational platforms, online courses, and the modernisation of institutional IT infrastructure (European Commission, 2025a). However, the level of institutional autonomy remains

significantly higher in the Netherlands, where colleges have full responsibility for organising exams and managing "lump sum" funds, whereas Ukraine continues the transition toward genuine financial and academic autonomy.

For Ukraine, the Dutch experience is extremely valuable in the context of developing social partnerships and forming a resilient work-based learning ecosystem. Establishing an institution analogous to the Dutch SBB could systematically resolve the gap between labour market requirements and VET content in Ukraine, ensuring transparent accreditation of internship sites and quality control of workplace mentoring. Developing an internal quality assurance system for vocational education based on self-assessment and reflection is another promising direction for modernising the Ukrainian system. In the Netherlands, self-assessment is viewed not as a bureaucratic obligation but as a tool for strategic dialogue within the institutional team and with its external partners (Köppe et al., 2025). Research indicates that involving learners and teachers in self-assessment processes increases their responsibility for learning outcomes and fosters agency the ability to actively influence the quality of the educational process.

In the context of deepening integration processes, the development of flexible learning pathways and the implementation of a micro-credentials system is of particular importance, becoming a shared vector for VET development in both countries in 2026. The Dutch "Npuls" initiative, aimed at the digital transformation of VET, creates conditions for the recognition of short-term learning modules, allowing specialists to update their competencies rapidly in accordance with the demands of the "green" economy and Industry 4.0. For Ukraine, the implementation of similar mechanisms, as outlined in the MES Strategic Plan until 2027, is not only a matter of economic expediency but also a strategic tool for the social rehabilitation and professional reintegration of veterans and internally displaced persons. Quality in this regard ceases to be a static characteristic of a diploma and transforms into a dynamic portfolio of verified skills, where each educational block undergoes validation via digital platforms, ensuring transparency and trust among all labour market participants. Such an approach requires a radical revision of curriculum development methodology: moving from rigid, long-term standards to modular structures that can be quickly adapted without losing the fundamental quality of vocational training. Simultaneously, a critical success factor for both models is the development of pedagogical leadership and the changing role of the teacher, who in modern conditions evolves from a transmitter of knowledge into a facilitator and designer of the educational environment. In the Netherlands, the shortage of teaching staff stimulates investment in their professional development based on the "professional space" concept, where educators have autonomy in choosing teaching methods and assessment tools provided they meet national quality indicators. In Ukraine, the modernisation of pedagogical education, as envisaged by new legislative acts of

2024–2025, focuses on bridging the technological gap and mastering blended learning tools. Teaching quality becomes a central element of the SSEQU institutional audit, as the level of professional and digital competence of a practical trainer directly correlates with the level of student skill development. Creating joint internship programmes with business for teachers at VTCs and Centres of Professional Excellence allows for the synchronisation of the educational process with real production cycles, minimising the risks of training specialists for "yesterday's" economy and increasing the overall attractiveness of vocational education among youth. A fundamental basis for ensuring the resilience of these systems in the long term is the transition to data-driven management, which enables predictive modelling of labour market needs and the effectiveness of educational investments. The implementation in Ukraine of automated systems for monitoring graduate employment, similar to Dutch tracking systems (ROA), provides an objective basis for management decisions at regional and institutional levels. This allows for the realisation of the "performance-based funding" principle, where quality directly influences the volume of state support, incentivising VET institutions toward active competition for applicants and employer trust.

In summary, it can be asserted that quality assurance systems in vocational education in the Netherlands and Ukraine are evolving toward greater flexibility, digitalisation, and close cooperation with the labour market, guided by EQAVET principles. For Ukraine, the successful implementation of European standards, combined with the adaptation of best Dutch practices, provides the foundation for creating prestigious and effective vocational education capable of ensuring sustainable post-war recovery and a high quality of life for citizens. A key success factor in this process will be not only legislative updates but also the building of trust among all participants in the educational ecosystem, where quality is recognised as a shared value and responsibility. This will enable Ukrainian graduates to be competitive in both domestic and European labour markets, facilitating Ukraine's integration into the single EU educational and economic space. Thus, the transformation of vocational education in both countries occurs under conditions of high uncertainty, necessitating that quality assurance systems possess "skills foresight" capabilities. The Dutch "Lifelong Learning Catalyst" model and the Ukrainian initiative (DECIDE) demonstrate the importance of regional ecosystems, where vocational education institutions become hubs for community development and economic growth. Integrating these efforts at the national level contributes to the resilience of vocational education against any global challenges, turning it into a powerful engine of societal progress. The prioritisation of investment in pedagogical staff, digital infrastructure, and the inclusivity of the educational environment remains a constant for the successful development of vocational education in the long term.

1.4. MODERN STRATEGIES AND PRACTICES OF QUALITY ASSURANCE IN VOCATIONAL EDUCATION: THE CASE OF DENMARK

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The section examines contemporary approaches to quality assurance in Denmark's vocational education and training (VET) system and identifies universal strategies applicable to other countries. Drawing on analytical reports by CEDEFOP, the European Commission, EQAVET and national Danish institutions, the article outlines how Denmark has developed a coherent, evidence based and labour market oriented model of VET governance. Key elements include the strong role of the Danish Evaluation Institute (EVA), a robust accreditation system, institutional autonomy combined with accountability, and the strategic involvement of social partners through sectoral councils. Based on Denmark's experience, the article identifies five universal strategies shaping modern VET quality assurance: evidence based governance, social partnership, institutional accountability, labour market relevance and digital transformation.

Keywords: *vocational education and training; quality assurance; Denmark; EQAVET; governance; social partnership; accreditation; digitalisation; labour market relevance*

Ensuring the quality of vocational education and training (VET) is one of the key challenges facing contemporary education systems operating under conditions of rapidly evolving labour market demands, digital transformation, and increasing qualification requirements. Over the past two decades, the European VET area has been developing shared approaches to quality assurance, reflected in the introduction of the European Quality Assurance Framework for Vocational Education and Training (EQAVET) and the Common Quality Assurance Framework (CQAF). Both frameworks articulate the principles of transparency, evidence based decision making, and continuous improvement (European Parliament & Council, 2009; European Commission, 2009). Within this context, Denmark occupies a leading position in Europe, owing to its coherent, institutionally balanced, and labour market oriented model of VET quality assurance.

Quality assurance in the Danish VET system is characterised by strong engagement of social partners, a well developed infrastructure for external evaluation, effective internal quality management mechanisms, and the integration of digital tools into monitoring and assessment processes (Radkevych, 2014).

The institutional architecture of VET quality assurance in Denmark is grounded in a robust system of external evaluation, the central component of which is the Danish

Evaluation Institute (EVA) (2021). A recent Cedefop review emphasises that the Danish VET system is "deeply rooted in a tradition of social dialogue and cooperation between schools, industry, and public authorities" (Cedefop, 2025e, p. 4). Within this framework, EVA functions as an independent analytical body responsible for quality monitoring, programme evaluation, and supporting institutions in developing their internal quality assurance systems.

One of the core functions of EVA is the systematic monitoring of VET system performance, which includes analysing indicators such as completion rates, graduate employment outcomes, dropout levels, and transitions between educational pathways. Cedefop notes that Denmark employs "comprehensive skills intelligence instruments and methods for forecasting future skills needs" (Cedefop, 2025e, p. 28), enabling EVA to ensure evidence based governance and maintain the relevance of training programmes. A significant area of EVA's work involves thematic evaluations that address specific dimensions of quality, including the effectiveness of the dual system, the quality of workplace based learning, and support for learners with additional needs. Cedefop emphasises that such evaluations contribute to the "continuous updating of curricula in line with technological and societal changes" (Cedefop, 2025e, p. 28). EVA also performs analytical and advisory functions, preparing recommendations, methodological materials, and tools for VET institutions (Cedefop, 2025c, p. 9).

The internal quality assurance system within Danish VET institutions constitutes a fundamental component of the national quality management model and is grounded in a combination of institutional autonomy, accountability for outcomes, and close cooperation with employers. Cedefop highlights that the Danish VET system is "deeply rooted in a tradition of social dialogue and cooperation between schools, industry and public authorities" (Cedefop, 2025e, p. 4), which shapes the nature of internal quality assurance mechanisms. These mechanisms do not operate in isolation but function as part of a broader ecosystem of interaction and shared responsibility.

All VET providers are required to develop and implement internal quality assurance systems based on the Plan–Do–Check–Act (PDCA) cycle. Annual quality reports, mandatory for all VET institutions, include an analysis of key indicators, survey results, and improvement plans, ensuring systematisation, transparency, and the possibility of external monitoring (Cedefop, 2025e, p. 6). Although institutions enjoy considerable autonomy in selecting tools and procedures, they remain accountable to the state through the national performance indicator system. Cedefop stresses that this model creates a balanced combination of flexibility and responsibility, which is a defining feature of the Danish system (Cedefop, 2020, p. 22).

A central element of internal quality assurance is the alignment of training programmes with labour market needs. Denmark implements a model in which workplace

based learning plays a pivotal role, and apprenticeship programmes constitute the foundation for career development within the VET system (Cedefop, 2025e, p. 5). Institutions are required to adapt programme content in accordance with the recommendations of the sectoral committees (Faglige udvalg), which define occupational standards, learning outcomes, and requirements for practical training. This approach ensures the relevance of programmes, their responsiveness to technological change, and their consistency with employer expectations (Cedefop, 2025b, p. 4).

The effectiveness of internal quality assurance systems is assessed through a comprehensive set of performance indicators, including completion rates, graduate employment outcomes, dropout levels, final exam results, and the quality of workplace based learning. Learner and employer satisfaction is another mandatory component of internal quality assurance. National surveys are conducted annually and cover issues such as teaching quality, organisation of the learning process, conditions of workplace training, and learners' overall experience. The latest Cedefop review (2025b, p. 3) further emphasises the importance of learner well being, indicating that internal quality assurance systems encompass not only academic outcomes but also psychological well being, learning support, and student engagement in governance.

The Danish model of internal quality assurance is grounded in a competence based approach, which prioritises the assessment of acquired professional competences rather than the mere assimilation of theoretical content. Digital portfolios, a key instrument for documenting learners' competences (Dibbern Andersen, 2020, p. 8), make it possible to record learning outcomes, demonstrate acquired skills, and ensure transparency in assessment. Institutions also monitor graduate employment outcomes, which serve as an important indicator of programme relevance and the capacity of VET provision to support successful transitions into the labour market.

Digitalisation has become a strategic direction in the development of internal quality assurance systems. Denmark prioritises preparing its VET system for the digital era and the green transition (Dibbern Andersen, 2020, p. 9), which directly shapes the instruments used by institutions: electronic platforms for monitoring learner progress, educational analytics for risk forecasting, online assessment tools, digital portfolios, and digital systems for coordinating workplace based learning. Cedefop highlights that the country employs comprehensive skills assessment instruments (Dibbern Andersen, 2020, p. 25), enabling institutions to adapt programmes in response to labour market and technological changes.

Programme accreditation is one of the key mechanisms of quality assurance in Danish vocational education and serves as an external control instrument aimed at confirming the alignment of programmes with national standards, labour market needs, and learning outcome requirements. Accreditation of Danish VET programmes is carried

out by the Danish Accreditation Institution (Danmarks Akkrediteringsinstitution) – an independent public body operating under the 2013 Accreditation Act (Danish Agency for Higher Education and Science, n.d.). Accreditation constitutes an essential component of the quality management system, ensuring transparency, accountability, and trust in VET outcomes (Cedefop, 2025e, p. 6). This approach establishes uniform quality standards across the VET system and guarantees that each programme meets state and labour market requirements.

The participation of social partners is one of the most distinctive features of the Danish VET system and a key factor underpinning its stability, relevance, and high quality. Cedefop emphasises that the Danish VET model is "deeply rooted in a tradition of social dialogue and cooperation between schools, industry and public authorities" (Cedefop, 2020, p. 27). This cooperation is institutionalised through the work of the sectoral committees – Faglige udvalg – which play a strategic role in shaping qualifications, updating programme content, and overseeing the quality of workplace based learning. These committees ensure a structural link between education and the economy, which is a defining condition for the effectiveness of the Danish model.

Sectoral councils are established on a tripartite basis, ensuring balanced representation of employers, trade unions, and the state. Their composition is approved by the Ministry of Education, which guarantees legitimacy, transparency, and alignment with national priorities. Cedefop describes the Faglige udvalg as "permanent bodies responsible for specific occupational fields", underscoring their systemic role in maintaining the quality of vocational training. Each council covers a particular occupation or a cluster of related occupations, enabling deep sector specific expertise and timely responses to developments within the corresponding economic sector.

One of the key functions of the Faglige udvalg is the development and revision of vocational qualifications. These bodies define occupational standards, learning outcomes, qualification structures, and requirements for workplace based training. This approach ensures a close connection between programme content and actual labour market needs. Denmark continuously updates its curricula in line with technological and societal changes, and the work of the sectoral councils makes this process systematic, continuous, and grounded in sectoral expertise (Cedefop, 2025e, p. 28).

Another important area of responsibility for the Faglige udvalg is the quality assurance of workplace based learning, which forms the core of the dual system. The councils establish requirements for enterprises eligible to host apprentices, monitor the conditions of workplace training, and ensure that practical learning aligns with occupational standards. This approach guarantees that workplace based learning is not a formality but a fully fledged educational environment in which key professional competences are developed.

The European Quality Assurance Framework plays a central role in shaping Denmark's approaches to VET quality management. The integration of national mechanisms with European standards ensures transparency, comparability, and coherence of qualifications within the broader European Education Area (Eurydice, 2025a).

An important element of EQAVET integration is the use of indicators that capture completion rates, graduate employment outcomes, dropout levels, learner and employer satisfaction, and the quality of workplace based learning. Denmark actively applies these indicators within both internal and external quality assurance mechanisms, enabling evidence based monitoring and ensuring transparency of outcomes. The Cedefop report (2025a, p. 12) emphasises that the country employs comprehensive skills intelligence tools, which constitute a key component of EQAVET implementation, particularly in forecasting labour market needs and adapting qualifications to economic change.

European frameworks also influence the development of digital quality assurance instruments. According to Cedefop (2023a, p. 12), Denmark "prioritises preparing VET for the digital era and the green transition", which is reflected in the use of digital monitoring platforms, learning data analytics, and electronic portfolios. These tools operationalise EQAVET principles of transparency, data accessibility, and continuous improvement, while enabling rapid responses to shifts in labour market demand.

A further practice illustrating the flexibility and adaptability of the Danish VET system is digitalisation, which has become a crucial instrument for ensuring quality. Researchers note that Denmark "prioritises preparing VET for the digital era and the green transition," a priority that shapes the strategic role of digital solutions in quality management (Dibbern Andersen, 2020, p. 10).

One of the key directions of digitalisation is the use of electronic monitoring platforms that track learner progress, assessment results, attendance, and completion of learning modules. These platforms provide real time access to data, enabling teachers and administrators to respond promptly to learner difficulties, adjust learning trajectories, and enhance the effectiveness of support measures. Digital monitoring systems constitute an essential component of internal quality assurance mechanisms, as they facilitate evidence based analysis and support the development of individualised learning approaches. This perspective is also reflected in the work of Ukrainian researchers examining digital transformation in education (Radkevych et al., 2025, pp, 15–16).

Learning analytics tools occupy an important place within the digital infrastructure, supporting the prediction of dropout risks, the identification of learners requiring additional support, and the analysis of programme effectiveness. Through these mechanisms, digital instruments function not only as tools for recording outcomes but also as instruments of strategic planning. Denmark actively employs such approaches,

aligning with broader European trends in the development of quality assurance systems and with EQAVET principles centred on continuous improvement and transparency.

Digital portfolios constitute another essential component of digitalisation. They are recognised as a "key instrument for documenting learners' competences", as they enable the recording of learning outcomes, the demonstration of acquired skills, and the enhancement of assessment transparency (Cedefop, 2020, p. 11). Portfolios also strengthen learner responsibility for their own progress and facilitate interaction between VET institutions and employers, who gain access to authentic evidence of training outcomes.

Examining the practices that underpin quality assurance in Danish vocational education allows us to illustrate how these practices correspond to global strategies for VET quality management. Contemporary VET systems in Europe and beyond demonstrate a convergence of quality assurance approaches, driven by shared challenges: rapid technological change, evolving labour market dynamics, increasing demands for transparency and accountability, and the need to integrate digital tools across all levels of governance. Analyses of European policies, CEDEFOP research, EQAVET documentation, and comparative reviews of leading VET systems reveal the emergence of five key strategies that shape the development of modern VET quality assurance systems (Cedefop, 2023a, pp. 2–4; Christensen & Juul Wiese, 2024, p. 34).

The first strategy can be understood as the transition toward evidence based governance, which entails the systematic use of data, indicators, and analytics for planning, monitoring, and improving vocational education. The Danish experience demonstrates convincingly that systematic data collection, analysis, and utilisation create the conditions for transparency, accountability, and continuous improvement. Within the Danish model, a central role is played by the Danish Evaluation Institute (EVA), which functions as the national analytical centre. EVA monitors system performance, conducts thematic studies, analyses indicators such as completion, employment, and dropout rates, and formulates policy recommendations.

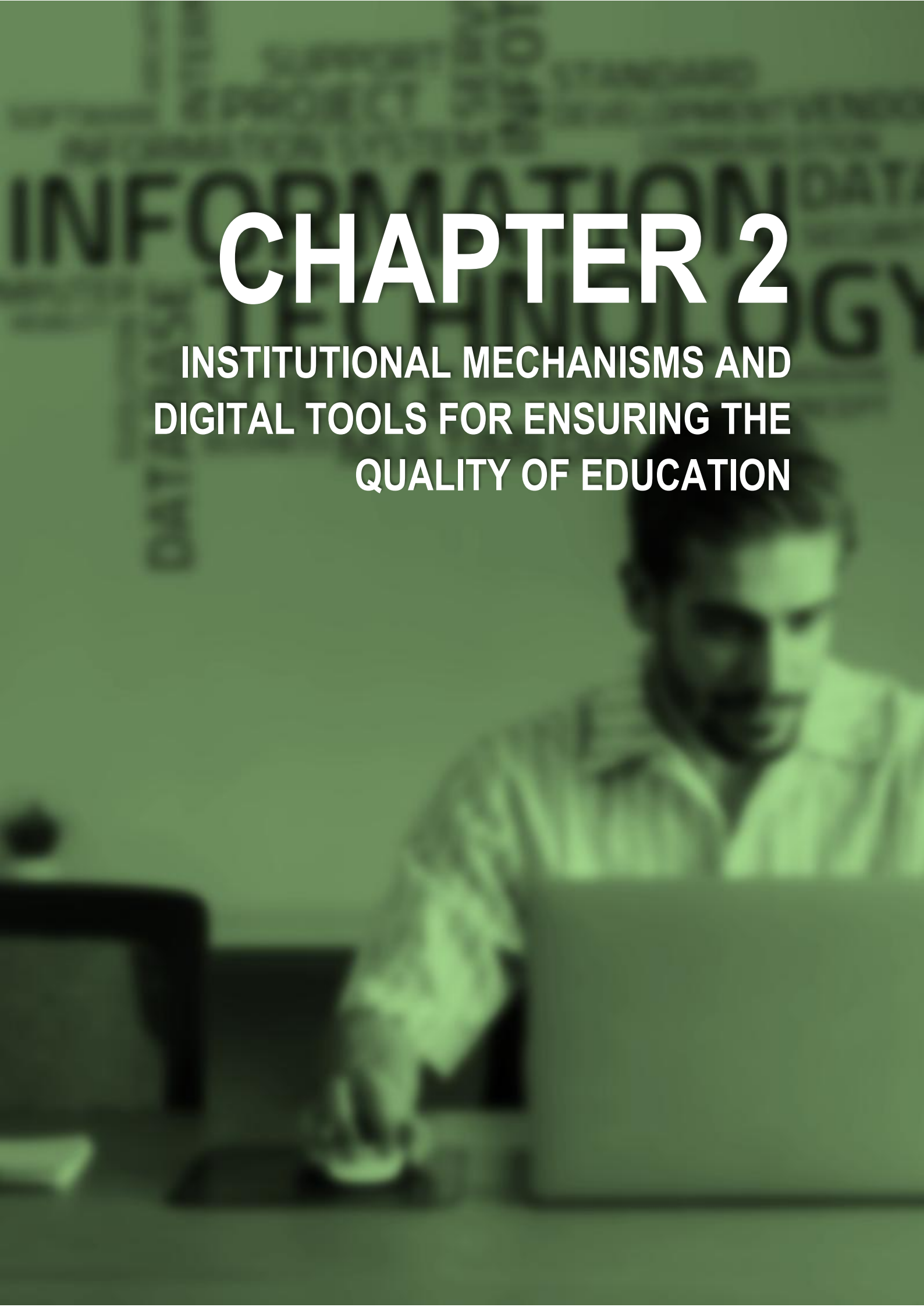
The second strategy is partnership based governance, which presupposes the institutionalised participation of employers, trade unions, and other stakeholders in shaping qualifications, updating standards, and overseeing quality. A comparative study of the systems of Germany, the Netherlands, and Norway conducted by Winch and Burgess (2025, p. 56) shows that the most effective VET models are built on platforms of "coordinated and consensual cooperation," where social partners act as co architects of qualifications. This approach ensures high labour market relevance of programmes and strengthens system resilience to economic change. The Danish experience is one of the most advanced examples of this trend, yet it reflects a broader European logic. The third strategy is institutional autonomy with accountability, which combines institutional

freedom in selecting quality assurance methods with clear mechanisms of responsibility. EQAVET reviews note that most EU countries employ programme accreditation, external monitoring, and mandatory quality reports as universal instruments of accountability. This model prevents excessive centralisation while maintaining common quality standards. Institutional autonomy is a crucial condition for the effective functioning of VET institutions; however, it must be paired with clear accountability mechanisms. The Danish model demonstrates that autonomy becomes productive only when institutions have the freedom to choose their methods but are required to demonstrate results. Danish VET colleges enjoy substantial self governance in organising learning, developing internal quality assurance systems, and managing resources. At the same time, they remain accountable through a system of performance indicators, annual quality reports, and external monitoring.

The fourth strategy is the orientation toward labour market relevance, which has become a central principle of contemporary VET systems. A comparative study by the Gatsby Foundation (Stuart Edwards, 2024, p. 15) highlights that successful vocational education systems are characterised by approaches in which employers participate in the development of qualifications, the definition of programme content, and the assessment of learning outcomes. Workplace based learning and the regular updating of qualifications serve as key mechanisms for ensuring relevance. This trend has intensified in response to rapid technological change and the growing need for flexible competences.

The fifth strategy is the digital transformation of quality assurance systems, which encompasses both internal and external mechanisms. The EQAVET report (European Commission, 2023a, p. 58) emphasises the need to assess the readiness of VET systems and institutions for digital change, indicating the integration of digitalisation into quality criteria. Digital dashboards, learning analytics tools, electronic portfolios, online assessment, and digital platforms for coordinating workplace based learning are becoming standard instruments in modern systems. Digitalisation ensures transparency, timeliness, and the possibility of individualised learning – factors that are critically important in the context of rapid technological change.

Digitalisation is not merely a tool of modernisation but a strategic foundation of the quality assurance system. Denmark demonstrates that digital solutions can operate across all system levels – from individual learner progress to national level monitoring. EVA actively uses digital dashboards, automated data collection systems, and electronic survey panels. Cedefop notes that digitalisation contributes to “strengthening learning and well being in the digital age,” underscoring its significance not only for governance but also for the quality of the learning environment (Cedefop, 2025f, p. 9).



CHAPTER 2

INSTITUTIONAL MECHANISMS AND DIGITAL TOOLS FOR ENSURING THE QUALITY OF EDUCATION

2.1. STRATEGIC GUIDELINES AND MECHANISMS FOR THE DEVELOPMENT OF THE QUALITY ASSURANCE SYSTEM IN VOCATIONAL EDUCATION IN UKRAINE

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This section outlines the strategic guidelines for the development of a quality assurance system for vocational education in Ukraine, ensuring its integrity, adaptability and effectiveness in response to current socio-economic challenges, sustainable development principles and European quality standards. The tools, procedures and measures of the external quality assurance system that influence the effectiveness of the internal quality assurance system in vocational education are examined. The requirements and rules governing the organization of educational and managerial processes for the development of a quality assurance system in vocational education institutions are analyzed, including the educational environment; the system for assessing students; the pedagogical activities of teaching staff and the management processes of vocational education institutions. Mechanisms for improving the internal quality assurance system have been identified, including compliance with and implementation of current legislation; the application of a competency-based approach to assessing learning outcomes and recognizing professional qualifications; the development of partnership models between vocational education institutions and business to create an innovative learning environment; systematic updating of teaching staff's professional competencies in light of digitalization, technological transformation and sustainable development principles; digitalization of management and educational processes; the formation of a quality culture in vocational education based on best international practices in vocational education and training quality assurance.

Keywords: *quality assurance system in vocational education; vocational education institution; vocational education students; teaching staff*

In today's environment the development of all sectors of the economy is characterized by instability, dynamic changes and the need for rapid adaptation under conditions of uncertainty. The war in Ukraine has significantly affected the supply of qualified professionals to the labor market and the shortage of such specialists is constraining national economic development. The importance of vocational education in addressing current challenges and rebuilding the country in the post-war period is unquestionable and reinforces the need to expand the capacity of vocational education institutions to provide high-quality educational services to youth, adults and vulnerable population groups in order to meet their needs for training, employment and decent work.

A flexible response of the vocational education system to societal demands requires defining strategic guidelines for the development of a quality assurance system that ensures its integrity, adaptability and effectiveness, taking into account current socio-economic challenges, sustainable development principles and European quality standards. Such a system should be aimed at achieving quality in vocational education, understood as "the alignment of learning outcomes with the requirements established by law, vocational education standards, professional and/or international standards (if applicable) and/or educational service agreements, as well as the needs of stakeholders and society, ensured through internal and external quality assurance procedures" (Verkhovna Rada of Ukraine, 2025c).

In Ukrainian research the features of the vocational education quality assurance system have been studied in the following areas: theoretical substantiation of key concepts within the context of education quality and the competency-based paradigm (Nychkalo, 2014); improvement of regulatory components of the vocational education quality system, including standardization, qualifications, professional standards and educational programs (Radkevych, 2021); modernization of management processes in the context of digitalization, particularly for the development of internal quality assurance systems (monitoring, self-assessment, management decision-making and human resources) (Yelnykova et al., 2023); adaptation of the national quality assurance system to international quality standards and harmonization of quality criteria (Verbovskyi, 2024); development of partnerships between vocational education institutions and employers and implementation of new mechanisms to ensure quality in vocational education (supervisory boards, advisory bodies, dual vocational education, etc.) (Kravets et al., 2023).

These research directions form the basis for specifying the strategic guidelines for the development of a vocational education quality assurance system in the context of updated legislation, which drives transformations in the interconnected subsystems of vocational education quality assurance. The vocational education quality assurance system is structured around three main components (Table 2.1).

In practical terms the components of the vocational education quality assurance system function in an integrated manner, ensuring that a holistic, open and dynamic quality management model, together with its mechanisms, tools, procedures and measures, meets the current requirements of the economy and society.

The provisions of the Law of Ukraine "On Vocational Education" (2025c) are being gradually implemented in the process of training future specialists in accordance with subordinate legislation. The introduction of legislative innovations in vocational education highlights the growing role of the labor market in ensuring education quality.

Table 2.1. Components of the vocational education quality assurance system

System name	Characteristics and instruments
Quality assurance system in vocational education institutions (internal quality assurance system of vocational education)	is established by a vocational education institution; *includes:* mechanisms for ensuring academic integrity; types of responsibility of teaching staff and vocational education students for specific violations of academic integrity; a system for assessing learning outcomes of students according to the relevant educational program; a system for evaluating the performance of teaching staff and other procedures, instruments and measures to ensure education quality defined by the vocational education institution.
External quality assurance system for vocational education	is implemented by the central executive authority in the field of education and science and the central executive authority responsible for ensuring education quality; *includes:* instruments, procedures, and measures aimed at ensuring and improving the quality of vocational education: standardization; licensing of educational activities; institutional audit; monitoring of education quality; attestation of teaching staff; certification of teaching staff.
Quality assurance system in the activities of management bodies, institutions, and authorities that perform external quality assurance of vocational education	*includes:* policies and procedures to ensure the quality of their own activities; necessary resources for organizing processes and procedures; external independent audit of the activities (processes and procedures) of the respective bodies and institutions.

For example, as of today, the Ministry of Education and Science of Ukraine has approved the Model Regulations on the Supervisory Board of a Vocational Education Institution and the Model Procedure for the Formation of a Supervisory Board of a Vocational Education Institution (Ministry of Education and Science of Ukraine, 2025). At the same time, several regulatory documents are under development, including: the procedure for practical training of vocational education students, a model student employment contract, regulations on the organization of dual vocational education, vocational education standards and others. This process involves engaging business representatives in the development of professional standards and educational programs,

the assessment of learning outcomes, the organization of dual vocational education and practical training and the establishment of qualification centers. Ensuring high-quality vocational education requires systematic alignment of training content for future specialists with the actual needs of the labor market, which is facilitated by partnership-based cooperation between vocational education institutions and businesses. The outcome of such cooperation is the development of modern professional standards included in the Register of Qualifications of the National Qualifications Agency. The content of professional standards is designed in accordance with the competency-based approach and defines professional competencies described through learning outcomes, the attainment of which certifies an individual's ability to successfully perform professional tasks and/or continue further education. Professional standards serve as the foundation for developing educational programs for specific full or partial professional qualifications and act as benchmarks for achieving high-quality training of future specialists.

Partnerships between vocational education institutions and the labor market provide broad opportunities for ensuring the continuous professional development of teaching staff. Professional development, attestation and certification of teaching staff (in accordance with current legislation) internships at enterprises, participation in master classes, training sessions, and innovative educational projects are the main forms of systematic upgrading of teaching staff professional competencies, taking into account technological advancements, digitalization of production processes and international trends.

The continuous enhancement of the professional, pedagogical and subject-specific competencies of teaching staff demonstrates their capacity to develop and implement pedagogical and production innovations in the educational process; create new educational resources, including digital ones; update educational programs, including short-term and inclusive programs, to ensure accessible and flexible learning opportunities and support the social integration of vulnerable groups; establish and sustain career guidance centers, training and practical centers, qualification centers and related structures. The expansion of international investment in the development of national vocational education contributes to the growth of partnership initiatives, grant programs and projects aimed at ensuring vocational education quality in accordance with European standards. Institutional mechanisms for quality assurance in vocational education and training in the European Union and Ukraine demonstrate significant similarities, including: professional standards, educational programs, competencies, qualifications, learning outcomes, internal monitoring criteria, self-assessment procedures, staffing and development of the educational environment.

In the context of ensuring high-quality vocational training for future specialists, it is important that vocational education institutions actively participate in international

projects aimed at modernizing institutional infrastructure and establishing centers of vocational excellence; updating vocational education content; strengthening cooperation with partners; developing educational resources, including digital materials; integrating advanced teaching methods and production technologies into the educational process; supporting the professional development of teaching staff.

Strategic guidelines for ensuring the quality of vocational education are aligned with the directions of modernization of the vocational education system in the context of contemporary transformations and are aimed at developing specific subsystems to achieve high-quality outcomes in the professional training of students. This approach involves not only maintaining an appropriate level of quality in the educational process but also establishing a system capable of responding effectively to labor market transformations, technological advancements, and social challenges (Table 2.2).

Table 2.2. Strategic guidelines for the development of the vocational education quality assurance system in Ukraine

Guidelines	Impact on the vocational education quality assurance system
Compliance with legislative acts and regulatory documents	interconnection of the components of the vocational education quality assurance system; transparency and academic integrity; openness and accessibility of educational programs; unified approaches to the formation, monitoring and self-assessment of the internal vocational education quality assurance system.
Competency-based approach to designing the content of professional standards and educational programs	alignment of educational program content with the requirements of professional standards; orientation toward learning outcomes; harmonization of procedures for assessing learning outcomes with legislation in the field of the national qualifications system.
Cooperation with employers and development of dual vocational education	introduction of new mechanisms for ensuring vocational education quality; participation of business representatives in the development of professional standards and educational programs; improvement of forms of practical training for vocational education students; implementation of dual vocational education; shared responsibility for the quality of specialist training; expansion of opportunities for the professional development of teaching staff.

Table 2.2. Strategic guidelines for the development of the vocational education quality assurance system in Ukraine

Guidelines	Impact on the vocational education quality assurance system
Innovation, digitalization and sustainable development	introduction of new professions and professional qualifications for priority economic sectors; implementation of innovative educational projects in partnership; modernization of material and technical resources in line with technological changes; application of digital tools in management and educational activities.
International integration	orientation toward European quality assurance standards in vocational education; participation in international projects and academic mobility programs; mutual recognition of qualifications.

The strategic guidelines for the development of a quality assurance system for vocational education in Ukraine are aimed at creating a comprehensive, adaptive, innovative and partnership-based model that ensures the relevance of vocational education to the current requirements of the economy and society. These guidelines form the foundation for the development of an internal quality assurance system, which is established by vocational education institutions and includes: "mechanisms for ensuring academic integrity; types of responsibility of teaching staff and vocational education students for specific violations of academic integrity; a system for assessing the learning outcomes of vocational education students under the relevant educational program; a system for evaluating the performance of teaching staff; and other procedures, tools, and measures to ensure education quality, as defined by the vocational education institution" (Verkhovna Rada of Ukraine, 2025c).

In vocational education institutions the establishment of an internal quality assurance system is regulated by the Order of the Ministry of Education and Science of Ukraine "On Approval of the Methodological Recommendations on the Formation of an Internal Quality Assurance System in Vocational (Vocational and Technical) Education Institutions" (Verkhovna Rada of Ukraine, 2021a).

In accordance with this Order, heads of vocational education institutions are recommended to approve Regulations on the internal quality assurance system, which provide for the development of a quality assurance strategy (policy) and related procedures. These Regulations define the guidelines for the functioning of the internal quality assurance system, take into account the interests of participants in the educational

process regarding the quality of educational services and the realization of their rights and comply with the principles of state education policy and educational activity.

The Regulations on the internal quality assurance system in vocational education institutions define the areas of assessment (the educational environment of the institution; the system for assessing students; the pedagogical activities of teaching staff; the management processes of the vocational education institution) and the requirements/rules governing the organization of educational and management processes and the functioning of the internal quality assurance system (Table 2.3).

Table 2.3. Areas of evaluation and requirements/rules for the organization of educational and management processes of an educational institution and its internal quality assurance system

Evaluation area	**Requirements / rules**
Educational environment of the institution providing vocational education services	Ensuring safe and harmless conditions for learning and work (internal educational environment of the institution)
	Ensuring safe and harmless conditions for learning and work (external educational environment of the institution)
	Ensuring safe and harmless living conditions in dormitories (if applicable)
	Creation of an educational environment free from all forms of violence and discrimination
	Formation of an inclusive, developmental and motivating educational space
	Provision of distance learning (if necessary)
Pedagogical activity of teaching staff	Effectiveness of teachers' planning and application of modern educational approaches to develop general professional, key and professional competencies of students
	Continuous professional development and improvement of pedagogical and professional skills of teaching staff
	Establishing cooperation with students, their parents (or legal guardians) and staff of the educational institution
	Organization of pedagogical activities and learner training based on academic integrity principles
	Availability of a transparent and clear procedure for evaluating the professional performance of teaching staff

Table 2.3. Areas of evaluation and requirements/rules for the organization of educational and management processes of an educational institution and its internal quality assurance system

Evaluation area	Requirements / rules
Management processes of the educational institution	Organizational and legal foundations of the institution's activities
	Formation of the learner contingent
	Availability of a development strategy, program and planning system, with monitoring of goal and task implementation
	Formation of trust-based relationships, transparency and adherence to ethical standards
	Effectiveness of personnel policy and provision of opportunities for the professional development of teaching staff
	Organization of the educational process based on a learner-centered approach and management decisions grounded in constructive cooperation among participants in the educational process and interaction with the local community
	Organization of the educational process based on constructive cooperation with employers (and employers' representatives), their organizations and associations
	Effectiveness (quality) of educational activities
	Formation and implementation of academic integrity policy
	Availability of a transparent and clear procedure for evaluating the managerial performance of senior staff of the educational institution
	Scholarship provision and social protection of students
	Rationality and efficiency in the use of available resources and material-technical base
Students' assessment system	Availability of a transparent, open and understandable system for assessing students' academic achievements
	Application of internal monitoring that provides systematic tracking and adjustment of each learner's academic progress
	Orientation of the assessment system toward fostering students' responsibility for their learning outcomes and their ability to self-assess
	Academic integrity of students

When defining the guidelines for the functioning of the internal quality assurance system it is essential to consider both current and future transformations in the field of vocational education, as well as labor market trends in today's dynamic environment. The establishment of policy priorities and procedures for the functioning of the internal quality assurance system in vocational education institutions requires the integration of modern approaches to quality assurance – including transformational, competency-based, European integration, systemic, regional (structural), partnership-based, and predictive approaches. These approaches are characterized by the adaptability of educational services to economic needs and regional demand for qualified specialists, as well as the flexibility of educational processes and mechanisms that ensure students' rapid access to the labor market and active participation in civic life (Kravets, 2025b).

Within the strategic development plans of vocational education institutions, ensuring the quality of professional training is defined as a key objective, supported by specific goals aligned with societal needs, labor market demands and trends in education and scientific development. The implementation of strategic plans aimed at improving the quality of professional training for future specialists requires the consolidation of efforts, expertise and innovation from both administration and teaching staff to achieve sustainable institutional development in partnership with employers. It also involves aligning learning conditions with real production environments, introducing innovative pedagogical and production technologies into the educational process and optimizing the allocation and use of resources.

The functioning of the internal quality assurance system in vocational education depends on the availability of effective tools, procedures and mechanisms associated with the external quality assurance system, including standardization, licensing of educational activities, institutional audits, monitoring of education quality and the attestation and certification of teaching staff. The internal quality assurance system is effective only when it is aligned with external control and evaluation mechanisms that define the standards, criteria, and directions for the continuous improvement of educational activities in vocational education institutions.

The strategic guidelines for the development of the national vocational education quality assurance system (compliance with legislative and regulatory acts; the competency-based approach to the design of professional standards and educational programs; cooperation with employers and the development of dual vocational education;

innovation, digitalization and sustainable development; international integration) are aimed at ensuring strong interconnections and mutual influence between the instruments of the external quality assurance system and the improvement of internal quality assurance mechanisms within vocational education institutions.

Systematic monitoring of the educational process based on surveys of all participants, timely self-assessment of management and educational processes and their continuous improvement in accordance with the development strategy of vocational education institutions and updated external quality assurance instruments constitute key drivers for enhancing the overall quality assurance system.

The integration and implementation of innovations that reshape approaches to the functioning of the vocational education quality assurance system require institutional strengthening of internal quality assurance mechanisms through: compliance with and implementation of current legislation; adoption of a competency-based approach to assessing students' outcomes and recognizing professional qualifications; development of partnership models between vocational education institutions and businesses to create innovative learning environments; systematic upgrading of teaching staff competencies in light of digitalization, technological advancements and sustainable development principles; digitalization of management and educational processes; formation of a quality culture in vocational education based on best international practices in vocational education and training.

2.2. SYSTEMIC APPROACH TO ENSURING THE QUALITY OF SPECIALIST TRAINING IN AGRARIAN COLLEGES

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The section substantiates the methodological system for ensuring the quality of specialist training in agrarian colleges. A definitional analysis of the basic research concepts ("quality", "quality of professional pre-higher education", "quality of educational activity", "quality assurance") has been conducted. Based on the rules of formal logic, the concept of the "quality of professional training of specialists in agrarian colleges" has been formulated as a comprehensive characteristic of the results of educational activity that reflects the degree of compliance of graduates' professional competences with the requirements of professional pre-higher education standards and the demands of the modern agrarian labour market. The structural and criterion characteristics of the pedagogical system as an ordered set of interrelated components forming an integral unity for achieving the goals of education and training are revealed. The methodological system is characterised and substantiated as a component of a higher-order pedagogical system, the internal quality assurance system in an agrarian college. A structural model of the methodological system for ensuring the quality of specialist training in agrarian colleges is presented.

Keywords: *quality of professional training, quality assurance, methodological system, agrarian college, model*

Under the conditions of contemporary global challenges, in particular those caused by the full-scale war with the Russian Federation and the transformation and modernisation of Ukraine's economy, the agrarian sector remains an extremely important strategic basis of national security and the main export potential of the state. The rapid development of scientific and technological progress and the transition to the Agriculture 4.0 model presuppose the introduction of precision farming systems, robotics, artificial intelligence, and wireless sensor networks (WSN), which have already become key innovations in modern agro-industrial production. Accordingly, the requirements for the training of middle-level specialists are changing significantly: professional junior bachelors must combine deep knowledge of the fundamentals of agricultural mechanisation, agronomy, and animal husbandry with skills in digitalisation, automation, and intellectualisation of all production processes, as well as decision-making based on big data analysis. Moreover, in the context of Ukraine's post-war recovery, the agrarian

sector will require thousands of qualified technicians, technologists, and middle-level managers capable of working effectively under conditions of limited resources and increased environmental standards.

For this reason, the problem of ensuring the quality of training of middle-level specialists in institutions of professional pre-higher agrarian education is becoming critically important. It should be added that ensuring the quality of specialist training in agrarian colleges is not only a pedagogical problem but also an economic necessity. The mismatch between the qualification level of agrarian college graduates and the requirements of the modern labour market may become a barrier to the post-war recovery of the agrarian sector. Therefore, the search for new mechanisms, technological resources, and tools for ensuring the quality of professional training of specialists in agrarian colleges is a strategic priority for the development of both professional pre-higher education and the agro-industrial complex of the country.

The scientific and theoretical foundations for addressing the problem of ensuring the quality of training of professional junior bachelors in agrarian colleges are provided by the works of numerous Ukrainian scholars. In particular, the studies by Hyrylovska (2020), Dutchak (2020), and Krasylnykova (2015) substantiate methodologies for ensuring and assessing the quality of professional training of skilled workers, bachelors, and masters. Of particular value for our study are the research outcomes presented in (Radkevych et al., 2018). In this work, having analysed the concepts, principles, models, and mechanisms of quality assurance in vocational education and training (VET) in EU countries, the authors reached the following conclusions: the European quality assurance system in VET functions at the macro level (the education system level), the meso level (the level of educational institutions), and the micro level (the level of the educational process). They further state that the quality of vocational education and training should be understood as the ability of education authorities and direct VET providers to satisfy established or anticipated needs of society, specific social groups, and citizens in acquiring professional competence and qualifications (Radkevych et al., 2018, p. 184). In addition, the research results presented in this work will be taken into account in our study.

From a practical standpoint, publications devoted to internal quality assurance systems in higher education are of interest. In particular, the training course Internal Quality Assurance System Based on European Standards, prepared within the Tempus project 544524-TEMPUS-1-2013-1-PL-TEMPUS-SMHES Qualifications Frameworks in Environmental Sciences for Ukrainian Universities (Safranov et al., 2017), characterises standards, highlights principles, and provides recommendations to the academic community regarding quality assurance in the European Higher Education Area. The detailed description of the internal quality control system of Jagiellonian

University, including a list of control questions for evaluating the curriculum, among other tools was relevant for our research.

In the analytical report Development of Internal Quality Assurance Systems in Ukrainian Higher Education Institutions (Finikov, & Tereshchuk, 2020), the results of a nationwide survey of 183 higher education institutions on the functioning of internal quality assurance systems, conducted by the National Agency for Higher Education Quality Assurance in November 2019, were analysed. The publication also includes recommendations for developing local quality management systems in Ukrainian universities, oriented towards different stakeholder groups. Importantly, the report examines the actual state of functioning of the components of the internal quality assurance system in dynamics (the results of the 2017 and 2019 studies are compared). That enabled well-grounded relevant conclusions.

Nevertheless, despite the large number of scholarly investigations into education quality, it should be noted that there is a lack of research that applies a systemic approach to ensuring (and assessing) the quality of specialist training in institutions of professional pre-higher education of the agrarian profile.

The aim of the chapter was, based on the analysis of the essential and substantive characteristics of education quality and educational practices, to propose a methodological system for ensuring the quality of professional training of specialists in agrarian colleges.

First of all, it should be noted that interest in ensuring the quality of professional training of specialists significantly intensified after the Berlin meeting of the Bologna Process participants in 2003. At this forum, experts in higher education agreed to develop such methodologies and technologies for assessing qualifications that would enable the comparison of students' learning outcomes across different universities. This development actualised the issue of education quality assurance and the interpretation of this phenomenon from the standpoint of competence-based education. At the same time, it cannot be asserted that there is unity of opinion among scholars, educational experts, and employers regarding the substantive meanings of the quality of specialist training, educational outcomes, and the technological aspects of their assessment.

Conceptual approaches to defining the quality of education, substantiated by British scholars Harvey and Green (1993, pp. 9-34), remain relevant today. The researchers distinguish five key aspects of understanding quality in higher education:

1. Quality *as excellence*. In this context, quality is equated with the elitism of an educational institution. It is determined by the concentration of resources: strong funding, modern infrastructure, highly qualified staff, and careful selection of applicants. Graduates of such universities are guaranteed thorough professional training, competitiveness in the labour market and, accordingly, high salaries.

2. Quality *as perfection or consistency*. This approach focuses on processes and standards. Quality is viewed as the result of continuous and systematic improvement, where the indicator of success is full compliance with established criteria and the stability of results compared with other higher education institutions.

3. Quality *as fitness for purpose*. Quality assessment is based on the extent to which learning outcomes correspond to the mission and strategic objectives of the university. Here, quality is not an absolute indicator but depends on the specific nature of the institution's activities and stakeholder expectations.

4. Quality *as value for money*. The focus is on the efficiency of resource utilisation. This approach reflects the demand of society and the state for the level of specialist training to be proportional to the funds expended. The university is accountable for learning outcomes to those who finance its activities.

5. Quality *as transformation*. This is the most learner-centred approach, emphasising qualitative changes in personal development. Quality is interpreted as the intellectual, social, and emotional evolution of the student during the learning process, the transition from lower to higher levels of competences and worldview.

Let us analyse the regulatory and legal acts that enshrine the understanding of the concepts under consideration. In this regard, the Law of Ukraine On Education (Verkhovna Rada of Ukraine, 2017a) defines the following terms: quality of education as the compliance of learning outcomes with the requirements established by legislation, the relevant education standard and/or the contract for the provision of educational services; quality of educational activity as the level of organisation, provision, and implementation of the educational process that ensures the attainment of quality education by learners and meets the requirements established by legislation and/or the contract for the provision of educational services. Article 41 of this Law further specifies that the quality assurance system in educational institutions constitutes the internal quality assurance system of education. It is also determined that, alongside this, there exists an external quality assurance system and a quality assurance system in the activities of governing bodies and institutions. Learning outcomes are defined here through an extremely broad complex of personal achievements: knowledge, skills, abilities, ways of thinking, views, values, and other personal qualities acquired in the process of education, upbringing, and development, which can be identified, planned, assessed, and measured and which a person is able to demonstrate upon completion of an educational programme or its individual components.

In the general provisions of the Law of Ukraine On Professional Pre-Higher Education (Verkhovna Rada of Ukraine, 2019b), the concept of the quality of professional pre-higher education is defined as the compliance of the conditions of educational activity and learning outcomes with the requirements of legislation and the standards of

professional pre-higher education, professional and/or international standards (where applicable), as well as the needs of stakeholders and society, which is ensured through the implementation of internal and external quality assurance procedures. Article 17 of this Law specifies that the systems for ensuring the quality of educational activity and the quality of professional pre-higher education of an institution of professional pre-higher education together constitute the internal quality assurance system of professional pre-higher education.

It should be noted that the seemingly obvious concept of the quality of professional training of specialists is not explicitly interpreted in the aforementioned laws. Regulatory acts operate primarily with the categories of *quality of education* and *quality of educational activity*, whereas the *quality of professional training* is usually considered a derivative concept or a scholarly category used in pedagogy and management. Let us therefore turn to the interpretation of these concepts by contemporary scholars.

In the study of the theoretical and methodological foundations of monitoring the quality of professional training of garment industry engineers (Krasylnykova, 2015, pp. 51–52) defines the concept of the quality of professional training of specialists as follows:

- the quality of the components of the professionally oriented pedagogical system (educational goals, human resources, material and technical resources, instructional and methodological support, educational content, and educational technologies, etc.);
- the quality of the institutional conditions for the functioning of the pedagogical system of a higher education institution, external (influences of metasystems: society, economy, the state, the EHEA, etc.) and internal (the mission of the higher education institution and the goals of its implementation; the educational environment including material and informational components; the management system, including the organisational structure; management technologies and resources; quality management; quality assurance and monitoring of the quality of educational activity and higher education, etc.);
- the quality of outcomes (learning and social). Learning outcomes include students' learning achievements (entry, interim, and final). Social results include indicators of satisfaction with the quality of the acquired training among participants in the educational process and beneficiaries.

As can be seen from the above definition, the researcher considers the macrostructure of the concept quality of professional training of specialists in the context of three meanings: the quality of the components of the pedagogical system; the quality of the conditions for the functioning of the pedagogical system; and the quality of educational outcomes. If the definition proposed by Krasylnykova (2015, pp. 50–51) is viewed through the prism of the interpretations of related concepts in the Law of Ukraine

On Professional Pre-Higher Education (Verkhovna Rada of Ukraine, 2019b), it becomes evident, in our opinion, that it essentially refers to the quality of education in general.

Researchers of the problems of monitoring the quality of professional pre-higher education at the Institute of Vocational Education of the National Academy of Educational Sciences of Ukraine interpret the quality of professional training of specialists as the compliance of learning outcomes with the requirements of professional pre-higher education standards (where available) and educational and professional programmes, as well as with the needs of society, the labour market, employers, and the individual (Kalensky et al., 2020). As can be observed, this definition employs an exclusively results-based approach: learning outcomes are identified as the principal generic feature. However, although the specific feature of "compliance with standards…" is significant, in our view it does not constitute a sufficiently distinctive specific difference in relation to the main generic concept. The results-based approach (compliance with standards) captures the "snapshot" of knowledge at the output stage but does not explain through which resources, technologies, and conditions this result has been achieved. The quality of professional training is not only the "product" but also the quality of the process itself (teaching, environment, practical base). Therefore, the specific distinguishing feature should include not only the result but also the nature of interaction among the subjects of the educational process.

Guided by the rules of formal logic (a definition must be proportional; must not contain a logical circle; must be clear and precise; and must not be reduced solely to negation), we formulate the definition of the concept under study as follows: *the quality of professional training of specialists in agrarian colleges is a comprehensive characteristic of the results of educational activity that reflects the degree of compliance of graduates' professional competences with the requirements of professional pre-higher education standards, the demands of the modern agrarian labour market, and the needs of the individual, and is ensured through the functional interaction of the components of the educational process, continuous and objective monitoring of learners' academic achievements under conditions of student-centred learning.*

The categories of quality assurance of education and quality management in education also remain within the field of researchers' attention. As Krasylnykova (2015) noted, the development of the term quality management in education has been influenced by ISO standards (p. 48). Quality Management Systems – Requirements, quality management is defined as coordinated activities to direct and control an organisation with regard to quality. According to ISO 9001:2015, quality management structures the following components (International Organization for Standardization, 2015):

- *Quality Planning*: determining the standards and requirements that a product or service must meet, as well as developing the processes to achieve them; at this stage, objectives are set and control methods are selected;
- *Quality Assurance (QA)*: creating confidence that quality requirements will be fulfilled; QA focuses on processes for preventing defects (for example, process audits, staff training, selection of reliable suppliers);
- *Quality Control (QC)*: verification of results for compliance with requirements; QC focuses on the product itself and on detecting defects after they occur (testing, inspections, measurements);
- *Quality Improvement*: continuous analysis of results to enhance processes; this includes handling complaints, eliminating the causes of defects, and implementing innovations to increase efficiency.

In turn, ISO 21001:2025 *Educational organizations – Management systems for educational organizations – Requirements with guidance for use* declares the process approach as a fundamental principle of quality management, the key components of which are the Deming cycle "Plan–Do–Check–Act" (PDCA) and risk-based thinking. It is emphasised that an educational organisation must plan and implement its activities taking into account "risks and opportunities" (International Organization for Standardization, 2025). Anticipation of risks and the possibilities for overcoming them is aimed at preventing negative impacts, achieving improved results, and, in general, serves as a source and basis for enhancing the effectiveness of the quality management system. These requirements will be taken into account in substantiating and developing the methodological system for ensuring the quality of specialist training in agrarian colleges.

First, it is necessary to clarify the essence of such concepts as system, pedagogical system, and methodological system. Analysing the nature of simple and complex systems, Lodatko (2021) defines this phenomenon as a set of elements whose quality, under certain external conditions, is determined by its internal composition and structure. Drawing on the principles of synergetics, the researcher emphasises the differentiation of systems: if the interaction of components generates new (emergent) properties not inherent in individual elements, the system is classified as complex; otherwise, it is considered simple. At the same time, the author rightly notes that the complexity of an object is determined not by the number of its components but by the possible ways of their interaction (p. 24).

At this stage of the study, the following generalisation should be made: for a social construct to be classified as a system, the object must meet the following criteria (Titova et al., 2023):

- presence of components (elements): an element is the minimal unit endowed with the basic properties of the system; quantitative limits may vary from two components to an unlimited set;
- diversity: each element possesses specific properties and a model of behaviour that distinguish it from other parts of the system;
- structuredness: the presence of stable connections and relationships in which a change in one element causes transformations in others;
- integrativity (emergence): the appearance of new qualitative characteristics in the system that none of its components possesses individually;
- identifiability: the possibility of isolating any component from the system (conditionally or actually, relatively or absolutely);
- hierarchy: vertical subordination in which higher-level subsystems have the right to intervene in lower-level processes, and the effectiveness of the entire structure depends on the functioning of each of its levels;
- functionality: the presence of clearly defined functional characteristics both in the system as a whole and in its individual components;
- stability: the ability of the system to maintain key parameters within the norm under the influence of internal or external factors;
- purposefulness: the orientation of the functions of all components towards achieving the unified goal of the system;
- communicativeness: interaction of the system with the external environment, as well as with systems of higher and lower orders;
- historicity and continuity: the presence of links between the past, present, and future; the inclusion in the structure of both past experience and prerequisites for further development;
- controllability: the ability of the system to perceive managerial influences (taking into account a certain natural resistance of the system to change).

Scholars demonstrate a general consensus that a methodological system is an integral set of hierarchically interconnected components forming a unified functional structure aimed at achieving educational goals. As a type of pedagogical system, it specifies the process of interaction between the teacher and learners through a particular content and toolkit. The study of the structural features and functioning aspects of pedagogical (methodological) systems allows the following conclusions to be drawn:

1. At present, within the Ukrainian scientific and pedagogical discourse, scholars demonstrate a diversity of views regarding the essence of the concepts pedagogical system, educational system, and methodological system, which are mostly differentiated on the basis of structural characteristics. Most often, the methodological system of

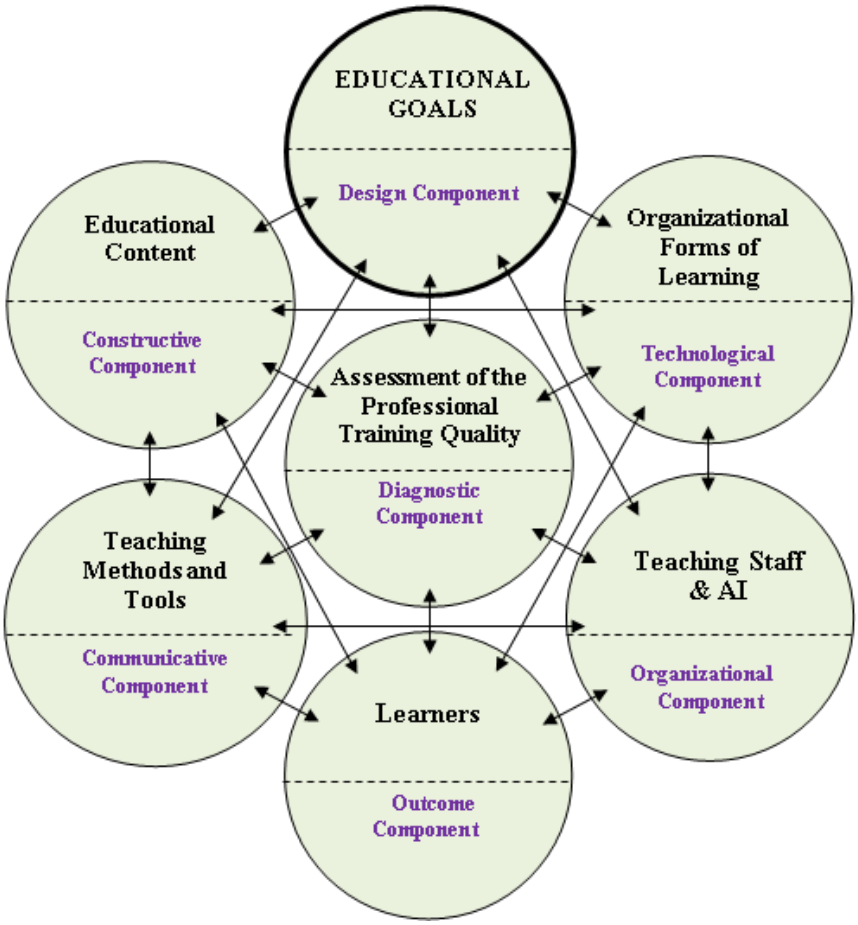
instruction is understood as an integral set of hierarchically interconnected components forming a unified functional structure aimed at achieving educational goals.

2. We consider the methodological system for ensuring the quality of professional training of specialists in agrarian colleges as a set of interrelated structural and functional components that integrate the resources of the college educational process and agribusiness, aimed at enabling learners to achieve standardised educational outcomes under conditions of student-centred learning and providing for continuous monitoring of students' competence achievements in order to promptly adjust the educational trajectory.

3. In accordance with the components of the holistic educational process, the structural components (subsystems) of the methodological system are defined as follows (Figure 2.1):

- *educational goals* are expected outcomes consisting in the training of a competitive specialist capable of effectively solving professional tasks in modern agribusiness;
- *educational content* is a scientifically grounded system of knowledge, skills, and competences selected in accordance with educational standards and the needs of contemporary agricultural production;
- *teaching methods and tools* is an integrated component of the methodological system and include: *teaching methods* (ways of organised, interrelated activity of the teacher and students aimed at achieving educational goals) and *teaching and learning tools* (a set of material and digital objects (laboratory equipment, machinery, simulators, e-platforms) that support the implementation of the educational process);
- *organisational forms of learning* are the external manifestation of the educational process that determines the order of interaction of participants in time and space (lectures, practical classes, training sessions, work-based practice);
- *learners* (as a subsystem) are the central subjects of the educational process who demonstrate cognitive activity, shape their own educational trajectory, and acquire professional competences through the integration of theoretical learning with practical experience in agricultural production;
- *teaching staff* (lecturers, masters of vocational training, etc.) are specialists who provide the professional training of highly qualified professional junior bachelors capable of finding their place in the agrarian labour market and actively engaging in the political, social, cultural, and other spheres of society from the first days of professional activity;
- *assessment of the quality of learners' professional training* is a real-time quality management tool of educational activity that ensures continuous feedback and adjustment of the educational process.

Figure 2.1. Structural model of the methodological system for ensuring the quality of professional training of professional junior bachelors in agrarian colleges



Thus, the study has demonstrated that, in order to purposefully and effectively ensure the quality of professional training of professional junior bachelors in an agrarian college, it is advisable to implement a methodological system that structurally and functionally ensures the continuous growth of learners' competence achievements through the integration of theoretical learning with practical experience in agricultural production. The developed system model represents an idealised view of the relationships among its structural and functional components and illustrates the modernising influence of the *Teaching Staff & AI* subsystem on the effectiveness of the educational process in a professional college.

Prospects for further research are associated with the development of valid digital-based tools for assessing the quality of specialist professional training in agrarian colleges.

2.3. INTELLIGENT EDUCATIONAL SYSTEMS AS A TOOL FOR MODERNISING MECHANISMS FOR ENSURING THE QUALITY OF VOCATIONAL AND PROFESSIONAL PRE-HIGHER EDUCATION

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The digital transformation of education drives the shift from paper-based documentation to integrated intelligent systems for managing educational data, which is especially relevant for vocational and pre-higher education under conditions of high learner mobility and an unstable educational environment. Intelligent educational systems (IES) provide personalized learning, automated assessment, and support for managerial decision-making based on big data analytics and artificial intelligence algorithms. The use of learning analytics enables early identification of academic risks, adaptation of learning trajectories, and increased transparency of internal quality assurance procedures. Effective integration of IES requires the development of a regulatory framework, digital maturity of educational institutions, and training of instructors and administrative staff. Beyond technical aspects, ethical standards, cybersecurity, and equal access to digital resources are essential. Implementing IES transforms educational process management and contributes to enhancing the efficiency, transparency, and resilience of the education system in the digital era.

Keywords: *digital transformation, intelligent educational systems, recognition of learning outcomes, digital micro-credentials, educational integration*

The digital transformation of education necessitates a shift from traditional paper-based documentation to integrated intelligent systems for managing educational data. In this context, the modernization of quality assurance mechanisms in vocational and professional pre-higher education acquires strategic importance, especially under martial law conditions characterized by increased learner mobility, the expansion of distance and blended learning formats, and the instability of the educational environment (Radkewycz & Pryhodij, 2025).

The application of a data-driven management approach involves the use of educational analytics systems and intelligent algorithms to process large volumes of data, enabling timely monitoring of learning outcomes, identification of risks of academic underachievement, and support for managerial decision-making based on objective indicators (Hegde et al., 2025, p. 7). Such an approach contributes to enhancing the transparency of internal quality assurance procedures, shifting from formalized reporting

to analytically grounded management, and fostering a digital educational environment in which the results of educational activities become the basis for improving educational programs and the strategic development of the educational institution.

The contemporary global scholarly discourse on the transformation of vocational and professional pre-higher education is characterized by a shift in focus toward the intellectualization of educational processes and the implementation of intelligent educational systems as tools for personalized learning. The concept of intelligent educational environments is associated with the transition to ubiquitous learning and the design of new pedagogical models based on adaptability and digital integration (Gros et al., 2016, pp. 3-23). Within this approach, intelligent tutors provide not only the automation of learning content delivery but also the adaptation of educational scenarios to the individual cognitive characteristics of the learner, the dynamics of their progress, and their learning style (Roll & Wylie, 2016, pp. 590–591).

A significant analytical tool supporting such systems is learning analytics, which is viewed as a means of systematically collecting, processing, and interpreting educational data to enhance learning effectiveness (Ifenthaler & Yau, 2020, p. 1984). Contemporary studies confirm that the use of analytics dashboards and predictive models makes it possible to identify academic risks at early stages and implement timely managerial interventions (Viberg et al., 2018, pp. 106, 108). In this context, comprehensive approaches to assessing the digital readiness of educational institutions are being developed, integrating indicators of institutional capacity for data-informed management (Chounta et al., 2024, p. 8).

A distinct research vector concerns the application of artificial intelligence to transform mechanisms of internal and external quality assurance in education. Scholarly literature emphasizes the potential of AI-driven quality assurance as a means of shifting from predominantly expert-subjective evaluation procedures to the analytics of large data sets, enabling more objective and evidence-based decision-making (Luckin et al., 2016, pp. 35–36). Systematic reviews demonstrate a rapid growth of research devoted to the use of AI in the educational sector while also highlighting the need to integrate the pedagogical dimension into technological solutions (Zawacki-Richter et al., 2019, p. 21).

The synergy of Big Data and machine learning methods opens up opportunities for building comprehensive models of learners' educational behavior, which within the concept of educational data mining is interpreted as the creation of a conditional "digital profile" (Pryhodii et al., 2022) or a student "digital twin" (Kartashova et al., 2024). In a broader socio-political dimension, such processes are associated with the formation of new digital modes of educational governance, where data become a key resource of education policy (Williamson, 2017, pp. 44–48).

At the same time, the development of intelligent educational systems is accompanied by a number of ethical challenges, particularly regarding algorithm transparency, the prevention of discriminatory practices, and the protection of learners' personal data (Holmes et al., 2019, p. 174). The issue of the ethical use of learning analytics and the need to establish clear principles of privacy are thoroughly substantiated in the works of Pardo and Siemens (2014), who emphasize the importance of balancing analytical effectiveness with respect for the rights of participants in the educational process.

The managerial dimension of the digital transformation of education is associated with the transition to evidence-based management, which involves making strategic decisions based on systematic data analytics. The development of the digital maturity of vocational and professional pre-higher education institutions is considered a prerequisite for the effective integration of intelligent tools into quality assurance systems (Chounta et al., 2024, p. 14; Viberg et al., 2018, p. 98). Research on educational technologies also indicates the growing role of digital environments in enhancing student engagement (Bond et al., 2020, pp. 12–13).

Empirical studies confirm the positive impact of intelligent and digital learning environments on learning outcomes. In particular, the meta-analysis by Chen and Liu (2024) demonstrates a statistically significant effect of smart classroom technologies on learners' academic achievement (pp. 13–14). At the same time, the effectiveness of such systems largely depends on the quality of feedback, which, according to the concept of Hattie and Timperley (2007), is a key factor in learning progress (pp. 86, 90–101).

Overall, the integration of intelligent educational systems into quality assurance mechanisms is viewed not only as a technological modernization but as a paradigmatic shift in the model of educational governance in the context of digitalization. This process is accompanied by critical reflection on the role of technologies in rethinking teachers' professional activity and the institutional autonomy of educational institutions (Selwyn, 2019), highlighting the need for a comprehensive interdisciplinary approach to modernizing quality assurance systems.

Despite the rapid development of digital technologies and the growing interest in the application of artificial intelligence in education, intelligent educational systems remain insufficiently integrated into the official procedures for licensing educational institutions and accrediting educational programs. Existing mechanisms of external and internal quality assurance are primarily focused on documentary verification of compliance with standards and formalized indicators, while the potential of educational analytics and automated assessment of learning outcomes is utilized only fragmentarily (Verkhovna Rada of Ukraine, 2021a).

In the Ukrainian vocational and professional pre-higher education sector, there is a lack of comprehensive conceptual models for implementing intelligent systems within the structure of internal quality assurance. Scholars emphasize that modernizing quality management requires a shift toward analytically grounded decision-making and the digitalization of procedures for monitoring educational outcomes (Hurzhii et al., 2025b). At the same time, a teaching and methodological manual on the digitalization of the educational process highlights the need to create integrated digital tools for recording and assessing learners' achievements, in particular through the implementation of electronic portfolios and automated data collection systems (Pryhodii et al., 2023, pp. 261–313).

Regulatory and methodological gaps in the use of artificial intelligence for assessing learning outcomes limit the possibilities for the legitimate application of automated algorithms in state oversight procedures. Ukrainian education legislation defines the general principles of quality assurance but does not include clear mechanisms for integrating educational analytics tools and AI systems into official monitoring procedures (Verkhovna Rada of Ukraine, 2017a). This results in a kind of regulatory vacuum, within which digital innovations are implemented locally, without systematic alignment with state standards and accreditation criteria.

Researchers of the digital transformation of vocational education emphasize that the effective integration of intelligent systems requires the development of clear regulatory frameworks, standards for the digital maturity of educational institutions, and procedures for verifying algorithmic decisions (Radkevych et al., 2025, pp. 15–16). Without appropriate regulatory support, automated assessment risks remaining an auxiliary tool with no legally defined status within the quality assurance system.

Thus, the lack of systematic regulation for the use of IES in licensing and accreditation procedures hinders the modernization of quality assurance mechanisms in vocational and professional pre-higher education. Bridging this gap requires the development of a conceptual model for integrating AI into the state quality monitoring system, the harmonization of the regulatory framework, and the implementation of standards for evidence-based (data-informed) management of the educational process.

An intelligent educational system is defined in contemporary scholarly literature as a complex hardware–software environment capable of dynamically adapting to the individual needs of the user based on artificial intelligence algorithms and machine learning technologies (Luckin et al., 2016, p. 18; Zawacki-Richter et al., 2019, p. 19). The key distinction of an IES from traditional learning management systems (LMS) is its three-component structure, which includes:

Student model – a profile of knowledge, cognitive styles, and psychotype that enables the prediction of a learner's behavior and educational needs (Baker, 2019, pp. 9–10; Holmes et al., 2019, pp. 97–98).

Subject area model – a knowledge ontology that structures learning content and defines the relationships between concepts (Chen & Liu, 2024, p. 2).

Pedagogical model – a teaching strategy that governs the individualization of the educational process and provides interactive real-time feedback (Hattie & Timperley, 2007, pp. 88–90; Roll & Wylie, 2016, p. 587).

This approach enables the system to function as a personalized tutor, simulating the behavior of an experienced educator and supporting active learning in the dynamic conditions of the educational process (Chounta et al., 2024, p. 6).

By functional purpose, IES can be classified into several main categories:

1. Adaptive platforms – adjust the complexity of content based on the learner's performance and progress, providing a personalized learning trajectory (Ifenthaler & Yau, 2020, pp. 1981–1982).

2. AI-driven decision support systems – assist administration in optimizing educational programs and resource planning (Bond et al., 2020, pp. 4–6; Hegde et al., 2025, p. 15).

3. Advanced educational analytics tools – allow visualization of hidden learning patterns, prediction of academic failure risks, and the formation of evidence-based decisions to improve educational processes (Viberg et al., 2018, p. 108; Williamson, 2017, pp. 28–32, 35–37).

4. Intelligent assessment systems and digital tutors (chat assistants) – automate routine communication, knowledge assessment, and provide rapid feedback, minimizing the human factor and enhancing learning efficiency (Luckin et al., 2016, p. 24; Chen & Liu, 2024, pp. 2–3).

The foundation of modern IES lies in machine learning and big data analytics technologies, which enable the system to autonomously improve based on experience gained from user interactions (Baker, 2019, pp. 4, 8, 10; Holmes et al., 2019, pp. 87–93). Natural language processing methods open up possibilities for automated assessment of open-text responses and essays, which previously could only be evaluated by humans (Roll & Wylie, 2016, pp. 584–586; Chen & Liu, 2024, pp. 2, 12). In addition, predictive analytics becomes an indispensable tool for the early identification of academic failure risks, allowing learners who require additional support to be identified in a timely manner before critical learning gaps occur (Ifenthaler & Yau, 2020, pp. 1980–1981; Hegde et al., 2025, p. 15).

Before integrating IES into vocational and professional pre-higher education institutions, it is important to understand their multi-level impact. intelligent educational system do not merely automate processes – they create an environment for continuous monitoring, analysis, and adaptation of learning, enabling the personalization of educational trajectories and enhancing the effectiveness of managerial decisions. In other

words, intelligent educational system become a bridge between data, pedagogical strategies, and the strategic management of the institution (Table 2.4).

Table 2.4. Intelligent educational systems as a tool for modernisation

Application Area of IES	Description and Functions
Transformation of the internal quality assurance system	Transition from one-time inspections to continuous automated monitoring. Collecting and processing data on student activity allows for the personalization of learning trajectories and the adjustment of programs based on progress. This enhances resource management flexibility and transparency in quality control.
Intelligent support for managerial decisions	Use of interactive dashboards and analytics for instant identification of problem areas in learning. Scenario modeling for institutional development allows assessment of risks when launching new programs or methodologies. Data-driven management ensures the effectiveness of strategic decisions.
Automation of assessment procedures	Implementation of electronic portfolios and AI-based automated testing systems ensures objectivity and transparency in evaluation. Students receive immediate feedback, while instructors are relieved from routine tasks. Digital traces are used to adapt materials in real time.
Educational analytics as a quality management tool	Implementation of evidence-based policy through in-depth analysis of student activity data. Predictive models forecast risks of academic failure, enable program adaptation to labor market needs, and identify in-demand skills. This increases management efficiency and supports continuous improvement of education quality.

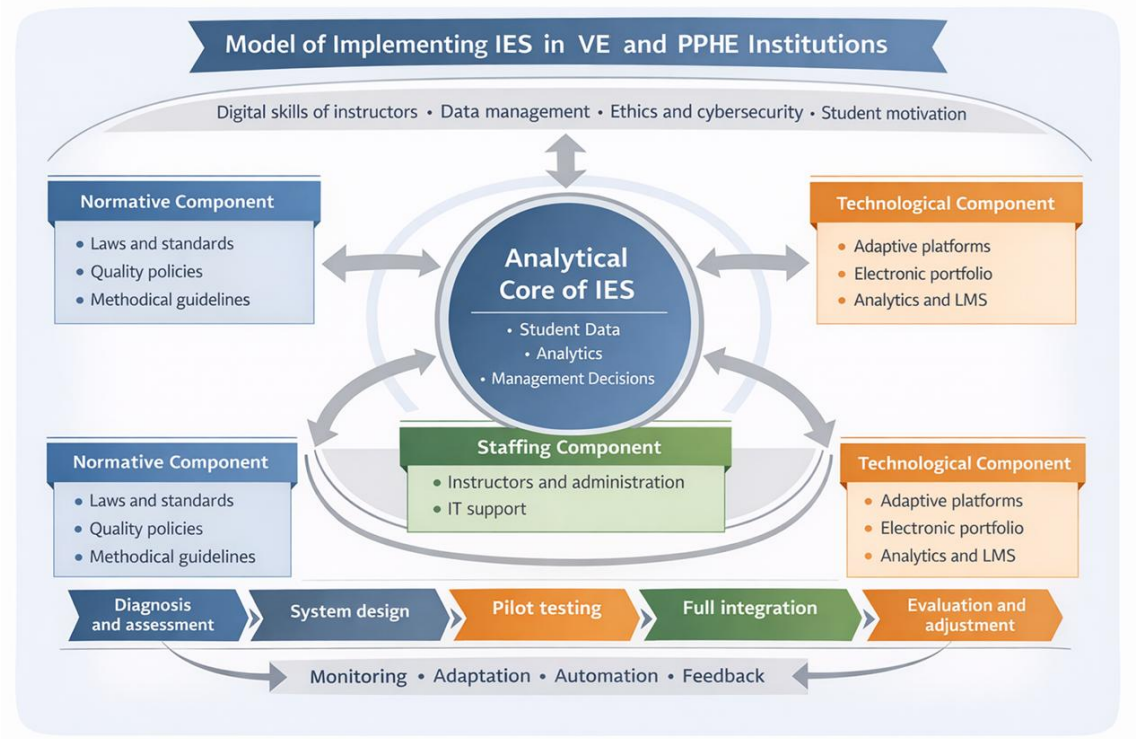
The proposed conceptual model for implementing IES in vocational and professional pre-higher education institutions is based on a triune approach, integrating regulatory, technological, and human resource components into a unified educational ecosystem (Figure 2.2):

The *regulatory component* encompasses the legal, methodological, and standard frameworks that govern the internal quality assurance system, the responsibilities of instructors and administration, as well as the rules for handling digital data and electronic resources.

The *technological component* involves the architecture of the IES, which includes a knowledge management module, an adaptive learning engine, an analytics system, and integration with students' electronic portfolios. It provides continuous collection, processing, and analysis of learning data in real time, enabling the creation of personalized learning trajectories and the rapid adjustment of educational programs.

The *human resource component* focuses on the digital and pedagogical competence of instructors, the administration's readiness to manage data and innovative technologies, and the involvement of IT specialists to support the system's infrastructure.

Figure 2.2. Conceptual model for the implementation of IES in vocational and professional pre-higher education institutions



These three elements are interconnected through the system's analytical core, which consolidates data on student progress, teaching effectiveness, and the outcomes of managerial decisions. The core ensures flexible interaction between components, allowing the educational program to be adapted to student needs, labor market requirements, and quality standards.

The implementation of IES in vocational and professional pre-higher education institutions occurs sequentially and includes several key stages:

Stage 1: infrastructure diagnosis – assessment of existing equipment, network resources, the digital literacy of instructors and administration, and the compliance of internal regulations with quality standards.

Stage 2: system architecture design – identification of the key IES modules, integration with LMS, digital libraries, and databases, and the creation of adaptive learning and analytics algorithms.

Stage 3: pilot testing – verification of the system modules' functionality on a limited sample of students and courses. At this stage, feedback from students and instructors is collected, and the effectiveness of adaptation and predictive algorithms is analyzed.

Stage 4: full integration into the educational process – gradual implementation of the system across all institutional units, connection of electronic portfolios, interactive dashboards, and automated assessment tools.

Stage 5: evaluation and adjustment – regular analysis of IES performance, updating adaptation algorithms and management models, and taking into account changes in the regulatory environment and labor market needs.

Each stage includes quality control and feedback mechanisms, which ensure the continuous improvement of educational practice and the system's resilience to external challenges, such as changes in curricula or employer requirements.

The effectiveness of IES depends on a range of pedagogical and organizational conditions:

- digital and pedagogical competence of instructors – the ability to use IES for personalized learning, data analysis, and generating recommendations for students;
- administration readiness to work with AI – includes data management, analytics-based decision-making, and modeling institutional development scenarios;
- adherence to ethical standards and cybersecurity – protection of students' and instructors' personal data, ethical use of predictive and assessment algorithms, and ensuring transparency in decision-making;
- student motivation and support – involves training students to use digital platforms, understand the principles of adaptive learning, and actively participate in the assessment process.

The system becomes effective only when technologies, people, and processes operate in synchrony, and the institution's leadership fosters a culture of data use for decision-making and continuous improvement of education quality.

The main challenges in implementing intelligent educational systems include algorithmic bias in artificial intelligence, which can lead to unfair assessment or discrimination against certain student groups. This requires the development of transparent algorithms, ongoing model auditing, and system adjustments in accordance with ethical standards. Another critical aspect is ensuring the confidentiality and security of personal data in cloud and online services, as centralized storage of large volumes of information makes them potential targets for cyberattacks.

In addition to technical and ethical challenges, the socio-pedagogical factor is also important. Teaching staff may often resist changes due to a lack of digital competence or fear of losing control over the learning process. Therefore, a critical condition for successful implementation is the systematic training of instructors, digital literacy workshops, and the creation of a supportive environment for sharing experience.

Equally important is the issue of digital infrastructure: uneven access to high-speed internet and modern computing resources across regions can limit the effectiveness of IES and create additional barriers for students. This requires an integrated approach, including government support for the development of digital networks, the establishment of local server solutions, and offline access to educational materials.

The practical implementation of the model requires a comprehensive approach, which includes updating the regulatory framework, establishing local educational analytics centers, developing human resources, and enhancing the digital literacy of instructors and administration. Additionally, adherence to ethical standards, protection of personal data, and ensuring equal access to digital resources for students across different regions are essential.

The successful implementation of IES in vocational and professional pre-higher education institutions requires a comprehensive approach to addressing technical, ethical, and social challenges, combining technological innovation with the enhancement of instructors' digital competence, the provision of cybersecurity, and equal access to resources for all participants in the educational process.

Thus, the integration of IES into vocational education institutions not only modernizes quality assurance mechanisms but also transforms the paradigm of educational process management, ensuring the efficiency, transparency, and resilience of the education system in the digital age.

2.4. ARTIFICIAL INTELLIGENCE AS A TOOL FOR ANALYTICAL SUPPORT OF QUALITY ASSURANCE SYSTEMS BASED ON INTERNATIONAL AND NATIONAL ASSESSMENTS

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The study substantiates the conceptual foundations for utilising artificial intelligence (AI) to provide analytical support for educational quality assurance systems, a task of critical importance amidst global digitalisation and escalating demands for institutional efficiency. It explores the potential of neural networks and Data Mining techniques for the in-depth processing of results from international (PISA, TIMSS) and national monitoring assessments, such as Ukraine's External Independent Evaluation (ZNO) and National Multi-Subject Test (NMT). Findings indicate that modern AI toolsets enable not only the automated detection of latent correlations but also the prediction of academic risks and the scenario-based modelling of educational reform impacts using Big Data. Particular emphasis is placed on the transition from static statistics to dynamic predictive analytics, which provides stakeholders with an objective basis for strategic planning and managerial decision-making. The study concludes that the integration of intelligent systems facilitates personalised learning and optimises managerial processes, thereby enhancing the overall competitiveness of national education on the global stage.

Keywords: *artificial intelligence, educational quality assurance, international and national assessment systems, predictive analytics, Big Data, managerial decision-making*

The contemporary paradigm of educational quality assurance necessitates a transition from fragmentary assessments toward comprehensive ecosystems, where artificial intelligence (AI) serves as the core analytical engine. The theoretical framework for this transformation is rooted in the theory of digital transformation in education, which comprises five sequential stages: from comprehensive data collection to continuous process improvement driven by acquired insights. In contrast to previous technological waves that merely automated existing administrative tasks, AI possesses the potential to fundamentally reshape how institutions gather, analyse, and synthesise complex data regarding instructional quality (Warren et al., 2026). This shift is facilitated by the capacity of algorithms to process unstructured datasets and identify patterns that remain inaccessible to traditional statistical methods. Integrating AI into the quality assurance system must be a measured process, encompassing infrastructure readiness assessments, strategic planning, pilot implementation,

scaling, and continuous performance monitoring via key performance indicators (KPIs). Such a systemic approach ensures that the technology is not merely deployed for the sake of innovation but becomes an effective instrument for enhancing institutional accountability and transparency (International Association for Quality Assurance in Pre-Tertiary and Higher Education, 2025).

A vital aspect of this conceptual justification is the shift toward proactive management, wherein real-time data allow for the identification of issues before they reach a critical threshold. The application of machine learning to monitor learner progress enables the automated tracking of compliance with accreditation standards (Campbell, 2025). This is particularly pertinent given the increasing variability of educational trajectories, where adaptive platforms dynamically adjust content and task difficulty based on student performance. Furthermore, the implementation of AI redefines the role of accreditation bodies: they are transitioning from static periodic reviews to continuous monitoring via intelligent dashboards that aggregate data on academic performance, research activity, and administrative efficiency. Under these conditions, every participant in the educational process receives personalised feedback and recommendations for further development.

New opportunities for interpreting the results of large-scale assessments, such as PISA and TIMSS, are provided by Data Mining techniques and artificial neural networks (ANNs). Traditional analytical methods, such as hierarchical linear modelling (HLM), frequently encounter limitations when processing thousands of variables and non-linear relationships between them (Huang et al., 2024). AI-specifically deep learning algorithms– effectively processes multidimensional datasets that incorporate not only test scores but also socio-economic factors, educational environment characteristics, and teacher preparation levels. Data Mining methods enable the extraction of the most influential factors determining learner success, utilising approaches such as Random Forest, Support Vector Machines (SVM), and XGBoost (Bayirli et al., 2023).

The Organisation for Economic Co-operation and Development (OECD) has officially announced the introduction of a new innovative domain within the PISA 2029 cycle: “Media and Artificial Intelligence Literacy” (MAIL), which effectively codifies technological and media literacy as a foundational skill equivalent to reading, mathematics, or science (OECD, 2026). This decision reflects the urgent need to assess learners’ ability not merely to use digital tools, but to interact with them critically, recognise sophisticated AI-driven manipulations, understand the profound ethical implications of algorithmic social governance, and collaborate effectively with intelligent systems as cognitive partners (Finnegan, 2025). The introduction of the MAIL domain responds to a world where content production, social media participation, and political engagement are increasingly mediated by algorithms, requiring learners to evaluate the credibility, quality, and intent of any digital media. At the core of the MAIL domain lies a conceptual fusion of media literacy and AI

literacy, reflecting the current state of the digital ecosystem where these two concepts have become inseparable. Media literacy in this context is viewed as the capacity to access, analyse, evaluate, create, and interact responsibly with information across various formats, allowing learners to question sources, identify bias, and communicate ethically (Wong, n.d.).

Leading global powers have already begun integrating AI competencies into national curricula, viewing this as a matter of economic survival and technological sovereignty. The United States, following a 2025 presidential executive order on "Advancing AI Education for American Youth", established a dedicated White House task force to develop online resources and foster public-private partnerships. Corporations such as Google, IBM, and NVIDIA have made significant commitments to train millions of learners and vocational educators in AI skills by 2028–2029, investing billions of dollars in the development of standards and infrastructure (The White House, 2025). In the US, the emphasis is placed on creating an "AI-ready workforce", which entails early access to technology and the integration of AI into courses on cybersecurity, programming, and general digital literacy.

South Korea's experience in 2025 has served as a serious warning to the international community regarding the dangers of overly rapid AI implementation without adequate infrastructure and teacher training. The ambitious "AI Digital Textbook Promotion Plan", which involved the rollout of 76 AI-powered digital textbooks for mathematics, English, and coding, effectively collapsed just four months after its launch (UNESCO, 2025). The programme faced sharp criticism due to technical glitches, AI-generated factual errors, and a significant increase in the workload for vocational educators who were forced to troubleshoot technical issues rather than teach. Parents initiated petitions against excessive screen time, fearing digital addiction and deteriorating child health, which led to these textbooks being downgraded from "primary" to "supplementary materials" (Securewithsaleh, 2025).

One of the most alarming findings of PISA 2022 was the widening gap between learners of different socio-economic statuses regarding access to digital resources. The lack of adequate devices and internet connectivity correlates directly with low academic performance; notably, learners from disadvantaged families and rural regions suffer most (Schleicher, 2024). In the age of AI, this divide risks becoming an "opportunity chasm", where those capable of using AI as an intellectual amplifier gain an exponential advantage over those who remain digitally isolated. Nevertheless, AI analytics also offer tools to address this issue (European Commission, 2024). The use of predictive algorithms allows teachers and institutional leaders to identify individuals at risk of "dropping out" of the educational process at an early stage by analysing data on attendance, grades, and online platform behaviour.

AI tools, such as AI graders or Socratic tutors, can scale quality education in regions lacking qualified teaching staff. In Brazil, an AI programme for essay assessment–trained on thousands of samples and verified by the national exam coordinator–enables teachers to

devote more time to individual work with learners instead of routine syntax checks. In Italy, researchers utilise AI to minimise gender bias during mathematics course selection, providing educators with objective data for guidance (Table 2.5). Consequently, international assessments like PISA 2029 serve not only as a measure of success but as a compass for directing state investment into targeted support programmes for those most at risk of being left behind in the era of smart machines.

Table 2.5. Global Experience of AI Application for Ensuring Equality and Inclusivity in Education

AI Analytics Application Example	Geography / Project	Expected Impact on Educational Equality
Automated Essay Grading	Brazil (Scaled in gov schools)	Equal access to instant feedback for 1:1 learning.
Voice Recognition for Reading	South Africa (Facebook), India (Pratham)	Assessment of reading skills in local languages in remote regions.
Algorithms to Mitigate Gender Bias	Italy (STEM tracking)	Recommendations for STEM trajectories free from stereotypes.
Personalised Chatbots (Rori, Khanmigo)	Ghana, Canada, Nigeria	24/7 access to tutoring for socially vulnerable groups.

The link between learners' use of AI and the future competitiveness of national economies is becoming increasingly evident. Projections suggest that the global education market will reach at least 10 trillion USD by 2030, with digital education growing at an annual rate of 16.3% (Nartey, 2025). The AI segment in education demonstrates even more impressive dynamics: the CAGR is projected at 31.2–42.8%, and the market volume could exceed 41 billion USD by 2030 (HolonIQ, 2020). This growth is driven by the transition toward a lifelong learning model and a massive demand for the personalisation of the educational experience (Table 2.6).

For the 15-year-olds participating in PISA 2029, MAIL skills will determine their ability to integrate into a labor market where the automation of routine tasks is expected to release human capital for high-value-added activities. Already, over 75% of young people believe that AI will play a decisive role in their professional future. Countries demonstrating high MAIL 2029 scores will effectively declare the presence of the intellectual resources necessary to create and manage AI systems, acting as a magnet for investment. Conversely, economies with low levels of AI literacy risk chronic skills deficits and social instability due to the displacement of jobs by automation without the capacity for rapid worker retraining.

Table 2.6. Projected Performance Indicators and Technological Structure of the Global AI Education Market (2025–2030)

AI Education Market Indicator	2025 Value	2030 Projection	CAGR (2025–2030)
Global Market Volume (Solutions/Services)	~$6.90 billion	~$41.01 billion	42.83%
Dominant Region	North America (36–43%)	Asia-Pacific	Rapid growth rate in Asia
Key Segment by Technology	Machine Learning (64.7%)	Generative AI / NLP	Highest growth rate for GenAI
Digital Education Spending (Total)	~$404 billion	~$850 billion	16.3%

One of the most significant challenges for educational policy is the so-called "pedagogical paradox" of generative AI. OECD research published in the "Digital Education Outlook 2026' indicates that while the use of AI chatbots (such as ChatGPT, Gemini, or Claude) allows learners to complete tasks faster and demonstrate higher-quality results, this does not always lead to knowledge consolidation. Moreover, excessive reliance on AI creates a risk of "metacognitive laziness", wherein a learner ceases to exert effort for deep information processing, leading in the long term to the degradation of cognitive endurance, critical thinking, and the capacity for sustained concentration (dpa GmbH, 2026). To mitigate this risk, the OECD recommends using AI not as an "answer machine" but as a "Socratic tutor" that asks guiding questions, prompting the individual toward an independent conclusion (Widen, 2026).

The transition from retrospective analysis to predictive analytics constitutes a key stage in the evolution of quality assurance systems. Predictive models utilising data from Learning Management Systems (LMS) and Student Information Systems (SIS) allow for the identification of risk groups during the initial stages of the educational process. Instead of reacting to academic failure after the semester concludes, AI algorithms analyse behavioural indicators–system login times, forum activity, and the speed of completing interim tasks–to generate signals for early intervention (Bird, 2023). The use of advanced machine learning algorithms, such as XGBoost, is three times more effective at identifying at-risk learners than traditional reliance solely on grade point averages. This is because AI accounts for dynamic changes in learner behaviour rather than merely static input characteristics. These models can also be used to optimise resource planning: predicting the number of students requiring additional consultations or tutoring support allows educational institutions to allocate budgets and teacher workloads more efficiently. Furthermore, predictive analytics serves as the

foundation for educational hyper-personalisation, where the system recommends individual learning materials or formats based on the learner's projected progress (Table 2.7).

Table 2.7. Functional Capabilities of Intelligent Analysis Systems

Application Scenario	Data for Analysis	Expected Result
Dropout Prediction	Attendance, LMS activity, socio-demographics	12–15% reduction in attrition
Early Warning	Interim tests, engagement in first 2 weeks	Timely tutoring support
Success Prediction	Previous grades, motivation, course difficulty	7–30% increase in performance
Resource Optimisation	Projected group sizes	Efficient staff and financial allocation

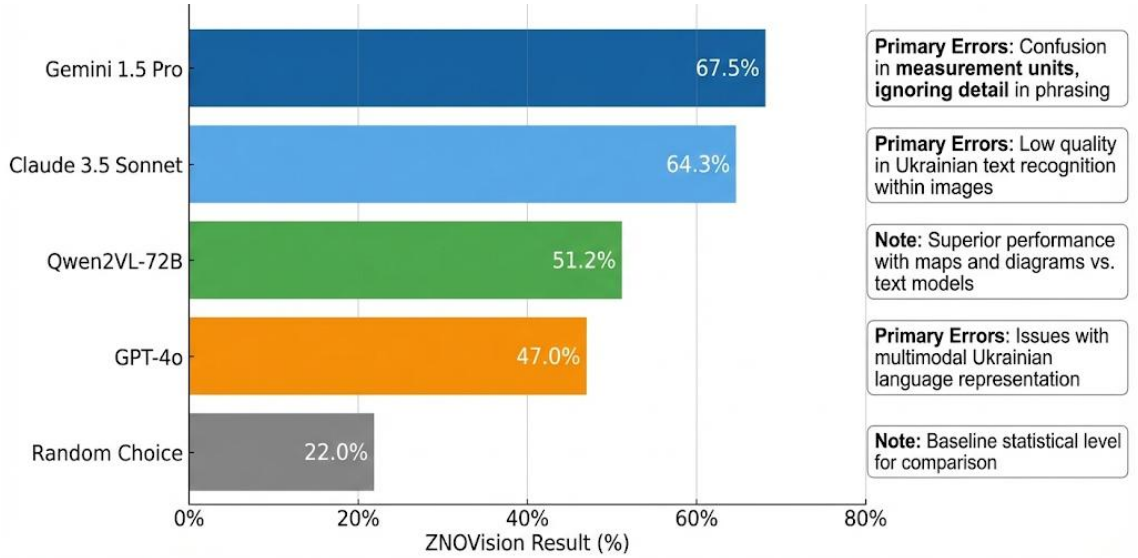
The Ukrainian educational system is currently actively seeking ways to integrate AI to enhance the reliability and objectivity of national assessments. The ZNOVision project represented the first large-scale attempt to test the capabilities of modern Large Language Models (LLMs) in solving ZNO and NMT tasks. The study revealed that although the models demonstrate a certain level of success (Gemini 1.5 Pro–67.5%, Claude 3.5–64.3%), they still face significant difficulties with the Ukrainian context, visual tasks, and specific terminology (Figure 2.3). This indicates the necessity of developing localised AI solutions trained on domestic educational content to ensure high analytical accuracy. The Ukrainian Center for Educational Quality Assessment (UCEQA) is considering the prospect of involving AI to grade open-ended NMT tasks, where the algorithm would act as a "third examiner" to minimise subjectivity and accelerate result processing (Lazurkevych, 2025).

In the Ukrainian context, burdened by the challenges of war, AI can also play a critical role in ensuring educational continuity through offline learning tools and the automated adaptation of materials for internally displaced learners. However, AI implementation in Ukraine remains fragmented and initiated primarily by individual institutions or educators, necessitating the development of a comprehensive state strategy and a strengthened regulatory framework (Hul et al., 2025). A vital aspect is also ethical oversight: learners and vocational educators in Ukraine demonstrate varying levels of trust in AI-driven monitoring of academic integrity, highlighting the need for a broad discourse on data transparency and security.

One of the most complex tasks for educational administrators is predicting the long-term consequences of reforms. AI provides tools for educational policy simulation, allowing for the evaluation of different intervention strategies before their practical

implementation. Algorithmic models built on Big Data from national monitorings indicate that improving teacher training and expanding access to technological resources can increase learners' academic performance by 18% and reduce dropout rates by 12% (Guevara-Reyes et al., 2025).

Figure 2.3. Comparative Analysis of Multimodal AI Model Performance in National Assessment Visual Task Solving (ZNOVision)



Such simulations are based on an analysis of model stability and sensitivity to changes in input parameters, enabling the identification of the most critical leverage points. Modelling also helps address the issue of inequality: AI systems can simulate reform impacts separately for rural and urban schools, and for private and public institutions, allowing policymakers to develop more balanced solutions. The use of Deep Reinforcement Learning enables the automated discovery of optimal pathways for educational resource allocation to maximise the cumulative reward–knowledge quality and learner motivation (Zheng & Lu, 2026). For instance, the IDQN model in educational simulations demonstrated the ability to increase learning interest and performance by 27–34% through personalised material mastery recommendations. Thus, AI transforms educational policy from an intuitive process into an exact science, where every decision is supported by a numerical analysis of probable outcomes.

The study results provide grounds to assert that the contemporary paradigm of quality assurance is undergoing a fundamental transformation under the influence of AI, transitioning from a static retrospective monitoring model to dynamic predictive analytics. Findings prove that deep learning algorithms, particularly XGBoost and BPNN architectures, are significantly more effective at identifying non-linear correlations between socio-economic factors and learner success than classical linear modelling. This establishes an objective

foundation for the transition toward proactive management, where the strategic decisions of ministries and institutional leaders are based on scenario modelling and digital twins of educational systems. In this context, the architecture of intelligent quality assurance must be viewed as a holistic ecosystem covering all stages of digital transformation: from automated Big Data collection to the creation of personalised value for every stakeholder. The global educational space, responding to digitalisation challenges, is effectively codifying technological literacy as a foundational skill, as evidenced by the introduction of the innovative "Media and Artificial Intelligence Literacy" (MAIL) domain in the PISA 2029 cycle. This decision marks the beginning of a new era of international competition for human capital quality, where the leadership of nations will be determined by their ability to integrate AI competencies into national curricula.

Consequently, technological transformation requires not only investment in soft and hard skills but also the formation of a social consensus and a culture of continuous professional development for vocational educators, who must become co-designers of intelligent educational tools. Addressing the "pedagogical paradox" of generative AI is of particular importance, where enhancing learners" short-term productivity via chatbots may be accompanied by the degradation of deep learning and cognitive endurance. To overcome the risk of "metacognitive laziness", it is necessary to transform the role of AI from an "answer machine" into a "Socratic tutor' that stimulates critical thinking and the independent pursuit of conclusions. Concurrently, intelligent analytics emerges as a powerful tool for ensuring educational equality, allowing for the early identification of risk-group learners and the provision of targeted support. The experience of using AI graders and personalised chatbots in countries across various income levels demonstrates the technology's potential to bridge the "opportunity chasm" caused by socio-economic status or geographical isolation, turning AI into an inclusive amplifier of society's intellectual potential.

For Ukraine, the integration of AI into national monitoring systems, such as ZNO and NMT, is a strategic priority that necessitates the development of localised language models adapted to the domestic cultural and educational context. Initial steps within projects like ZNOVision highlight the need to transition from fragmented initiatives to a comprehensive state policy regulating ethical aspects, data security, and algorithmic transparency. The use of AI for grading open-ended tasks and analysing applicant trajectories is capable of increasing the efficiency of administrative processes by 40%, which is critical amidst limited resources and wartime challenges. In conclusion, the future of educational quality depends on the ability to harmoniously combine the power of algorithmic systems with human pedagogical mastery, where AI serves not as a replacement for the educator but as a high-performance analytical partner in ensuring the global competitiveness of national education.

2.5. USE OF AI TECHNOLOGIES IN VOCATIONAL EDUCATION OF UKRAINE: CHALLENGES AND PROSPECTS FOR QUALITY ASSURANCE

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This section examines the use of artificial intelligence technologies in vocational and professional education in Ukraine, focusing on key challenges and prospects for ensuring educational quality. In the context of rapid digital transformation and the growing influence of AI systems such as ChatGPT, Google Bard, and IBM Watson, Ukrainian educational institutions are increasingly integrating intelligent tools into teaching, assessment, and administrative processes. The article analyzes how AI can support personalized learning pathways, automate routine tasks, enhance formative and summative assessment, and provide data-driven decision-making mechanisms to improve institutional performance. At the same time, particular attention is paid to existing barriers, including insufficient digital infrastructure, limited teacher preparedness, ethical and legal concerns, data protection issues, and the risk of academic dishonesty. The study highlights the need for a comprehensive regulatory framework, updated professional standards, and systematic teacher training to ensure the responsible and effective implementation of AI technologies. The paper concludes that while AI offers significant potential to modernize professional education in Ukraine and align it with European quality standards, its successful integration depends on balanced policies, institutional readiness, and a strong focus on maintaining academic integrity and human-centered learning principles.

Keywords: *artificial intelligence (AI), professional education, vocational training, educational quality assurance, digital transformation*

Scientific and technological progress, challenges, and modern trends in the development of vocational education necessitate the training of a competitive and professionally competent specialist who meets the requirements of the time and will be able to work under the current difficult conditions for our state. Such trends contribute to creating objective prerequisites for improving educational technologies for broad segments of the population, including the introduction of new forms of education. One of such forms is the informatization of education, which in the adopted comprehensive EU development strategy “Europe 2020” and, accordingly, in the program “Education and Training 2020” (Education and Training 2020 – ET 2020), was identified as a priority and one of the main directions of the framework digital competence that must be equally mastered by both teachers and students. One of such forms is the informatization of education, which includes various digital technologies and tools (Eurydice, 2018).

One of the most well-known among these tools is AI-technologies, which are increasingly being used in vocational education institutions in Ukraine. In our opinion, artificial intelligence (hereinafter – AI) opens new opportunities both for the professional development of teachers and for supporting their professional activities, becoming an indispensable tool for performing many types of activities, creating lesson notes, selecting auxiliary and demonstration materials, assessing student work, or tracking their progress. The use of AI allows teachers to work more efficiently and save time. AI systems can free teachers from a significant part of routine tasks, including grading, creating educational materials, and others.

According to its definition, artificial intelligence is a branch of computer science that deals with creating intelligent machines capable of performing tasks that usually require human intelligence and sometimes even surpass human abilities (such as the speed of mathematical calculations, rapid search for reference data on the Internet, and others), meaning it is a subfield of computer science related to the automation of intelligent behavior and machine self-learning. AIsystems are created to learn from experience, recognize patterns, and make decisions based on input data. These systems can be trained to perform certain tasks, such as recognizing and comparing images, understanding natural language, writing and editing texts, including translating from other languages while preserving even poetic rhymes, or playing games, etc. This is a rapidly developing branch of computer science focused on developing intelligent machines, a research field that creates and studies methods and software that allow machines to perceive the world and use self-learning and intelligence to perform actions that continuously increase their capabilities to achieve a defined goal (Wikipedia, n.d.).

AI is understood as the ability of a machine or computer program to think, act, and respond similarly to humans. The characteristics of AI include intelligent behavior, environmental analysis, and purposeful actions to achieve specific goals using certain degrees of freedom. It should be noted that there is still no single definition of AI, although the focus of researchers such as Yoshua Bengio, Luciano Floridi, Demis Hassabis, Geoffrey Hinton, Yann LeCun, Ray Kurzweil, Andrew Ng, Jürgen Schmidhuber, Josh Tenenbaum, and Thomas Wiegand is directed toward defining the content of this concept and its structure (Skvortsova & Symonenko, 2025).

Among Ukrainian scientists actively researching and implementing AIin education are the following: Oleksandr Romaniuk – intelligent systems and machine learning, Ihor Halat – AIin learning systems, Olha Shpakivska – computational intelligence, Mykola Novikov – AIin educational process management systems. Ukrainian scientists conduct important research and developments in the field of AIin education, contributing to further development of educational technologies and improving the quality of learning. Moreover, problems of using AIin education were

studied by Vizniuk and Koblyk, while AIas an innovative information technology in pedagogical research was analyzed in the studies of Huraliuk. Issues of AIapplication in educational environments: potential and challenges were addressed in the research of Melnyk (Huraliuk, 2023; Melnyk, 2023; Koblyk, 2024).

In December 2020, the Cabinet of Ministers of Ukraine approved the Concept for the Development of AI in Ukraine until 2030, according to which it is planned to implement AItechnologies in education, economics, public administration, cybersecurity, defense, and other sectors to ensure Ukraine's long-term competitiveness in the international market (Verkhovna Rada of Ukraine, 2020a). On December 9, 2022, the Minister of Education and Science of Ukraine presented the large-scale transformation program "Education 4.0: Ukrainian Sunrise" (Ministry of Education and Science of Ukraine, 2022), which was prepared by the Ministry of Education and Science of Ukraine based on the principles of Ukraine's Recovery Plan. To implement the Education 4.0 concept, it is necessary to ensure learners' access to modern technologies, appropriate infrastructure, and proper pedagogical support. The main technologies used in Education 4.0 include artificial intelligence, virtual reality, the Internet of Things, machine learning, and others.

The tasks of the AIDevelopment Concept until 2030 are as follows:

- improve legal regulation of AI, particularly in education, economy, public administration, cybersecurity, and defense;
- improve the quality of higher education and educational programs aimed at training specialists in AI; implement innovative projects using AI;
- increase the level of information security and data protection in information and telecommunication systems, etc.

The implementation of this concept will contribute to increasing Ukraine's competitiveness through the use of AIin socio-economic, scientific-technical, defense, environmental, national-cultural, and other spheres (Verkhovna Rada of Ukraine, 2020a).

In the near future, it can be expected that AItechnologies aimed at personalization and adaptability will revolutionize the way individuals (individual educational trajectories) and groups learn, improving both the educational process and group interaction. Their implementation will contribute to broader access to advanced digital technologies, expanding the share of research-based approaches in education and improving the quality of educational services.

The development of educational environments with AI elements for the professional development of teaching staff will contribute to the modernization of the scientific and educational process in higher pedagogical and postgraduate pedagogical education institutions, the effectiveness of implementing immersive technologies, cloud

computing tools and services, artificial intelligence-based systems, improving the quality of teacher training, and increasing their level of digital competence.

AI is gradually becoming one of the leading tools of digital transformation in vocational education. Its use contributes to improving the quality of specialist training, improving educational processes, and better matching educational content to the individual needs of learners. An example of using AI for learning personalization is that AI systems allow analyzing students' individual educational trajectories, identifying their strengths and weaknesses, their level of knowledge, and the pace of material acquisition. Based on this data, an individual learning plan is formed with appropriate selection of materials, tasks, and deadlines (Bezruchenkov & Shchuka, 2025).

AI allows the creation of personalized educational programs that take into account the individual needs and capabilities of each learner. By analyzing data on each learner's academic progress, AI systems can suggest next steps and tasks optimized for maximizing the development of each learner's potential. AIcan be used to automate routine tasks such as test checking, grading assignments, and even providing individual feedback to learners. With the help of artificial intelligence, it is possible to ensure accessibility of education for everyone, regardless of their location, physical abilities, or other limitations. It can be used to create online courses, interactive learning materials, and other resources that can be accessed from anywhere in the world.

AI provides the possibility of analyzing large volumes of data about learning and student interaction with educational materials. This makes it possible to identify trends, detect problem areas, and monitor student progress, allowing teachers and administrators to respond to their needs more quickly and improve educational programs. AI allows the use of innovative teaching methods such as virtual reality, interactive simulations, and games that provide more engaging and effective learning. In general, the use of AI in education can significantly improve the educational process, making it more efficient, accessible, and individualized for each learner. However, it is important to consider ethical and social aspects of implementing AItechnologies in education and ensure that the educational process preserves humanistic values and develops critical thinking skills among learners (Lubko & Sharov, 2019).

AI plays a key role in creating modern educational content. The NotebookLM tool from Google (2024). automates the generation of notes, tests, summaries, and even audio podcasts based on input data, which significantly saves teachers' time. For example, AI can create tests on occupational safety or technology adapted to the learners' level.

The Panopto platform (n.d.) has become an indispensable tool for organizing interactive online learning. It allows recording lectures, creating video guides, and adding

interactive elements such as tests or comments. Teachers can create libraries of learning materials accessible through QR codes, which increases the flexibility and accessibility of learning (Herevenko, 2025).

Regarding vocational education, AI opens the possibility not only to modernize learning tools but also to change the very logic of the educational process, making it competency-oriented, personalized, evidence-based, adaptive, and psychologically and pedagogically motivated.

The Institute of Vocational Education of the National Academy of Educational Sciences of Ukraine already plays an important role in this process by providing:

- Scientifically grounded approaches to the implementation of AItechnologies;
- Methods of teacher training;
- Assessment models using digital tools;
- Research on psychological and pedagogical changes in learners that determine the success of digitalization (Pryhodii, 2025).

Effective integration of AI into the professional education of future teachers is based on three interrelated conceptual approaches: instrumental, didactic, and competence-based. The instrumental approach considers AI as a high-tech tool whose main purpose is to optimize routine teaching and learning processes and ensure maximum individualization of the learning trajectory. This approach aims to teach future teachers to use AI systems as effective assistants (Alejandro et al., 2024).

In addition, AI systems can use algorithms for automatic checking of assignments and tests; recognize correct answers, process text responses, and even evaluate creative works, which reduces teachers' workload and accelerates the assessment process. Artificial intelligence can automatically analyze data on student performance, time spent on tasks, frequency of errors, and other parameters, generating reports and statistics for teachers and administrators (Dmytriieva & Yefymenko, 2023).

Also, AI systems can assist teachers in automating lesson planning and scheduling, resource allocation, and other administrative tasks. AI can automate communication processes with students, parents, and colleagues, for example by sending event notifications, distributing emails, or creating online discussion forums. It can help in creating, administering, and analyzing test and survey results to evaluate students' academic progress or collect research data. Automation of routine tasks using AI not only increases efficiency and speed of work but also frees up teachers' time for deeper analysis and individual support of learners (Vizniuk et al., 2021).

Furthermore, AI can use learning data analysis to develop adaptive learning programs and interactive tasks that are adjusted to the needs and abilities of each learner. AIcan also use gamification elements to create educational games and exercises that stimulate learners' motivation and interest, contributing to more effective knowledge acquisition. It can create chatbots that provide support and answer students' questions in real time, ensuring learning support at any time and from any location (Tkachuk, 2018).

Regarding vocational education, deeper research on the use of AI, especially in this field, can create new opportunities for studying adaptive learning systems and educational process automation, support the analysis of large data sets, improve simulation models, and develop new research approaches in materials science, mechanics, and production automation. It will also allow conducting complex experiments in virtual environments, accelerating the development of new materials and technologies. In addition, AI technologies can help optimize scientific research by reducing the time required to create prototypes and experimental models. In terms of educational platforms, AI can help create interdisciplinary digital laboratories integrating mechanical engineering, cybernetics, physics, and materials science.

Moreover, AI technologies help adapt educational programs to the requirements of the modern labor market. Analysis of market trends and forecasting the demand for specialists allow updating the educational content and preparing learners for modern technological challenges.

The use of AI technologies in the educational process opens new opportunities for conducting interactive, game-based, and virtual learning activities, including the use of virtual and augmented reality and the creation of intelligent educational games. At the same time, their accessibility helps ensure access to high-quality education regardless of place of residence. They enable the implementation of distance and online learning formats, providing flexible learning opportunities for students from different regions.

Overall, the implementation of AI tools in education aims to make the educational process more personalized, efficient, and innovative. However, it is also important to consider the challenges and potential risks associated with the use of AI in the educational environment.

The accessibility and popularity of generative AItools raise new issues of responsibility, confidentiality, and ethics in the educational field. Teachers and learners use AI systems such as ChatGPT, Copilot, Bard, LLaMA, Stable Diffusion, Midjourney, and DALL·E, which do not have clear consensus regarding compliance with the General Data Protection Regulation (GDPR). This regulatory document was adopted within the

legislation of the European Union to ensure the protection of personal data of all individuals in the EU and the European Economic Area. In the context of European integration, Ukraine is taking steps toward transparent, responsible, and ethical use of AI systems. As a member of the Special Committee on AI under the Council of Europe, Ukraine joined the OECD Recommendations on AIin October 2019 (Organisation for Economic Co-operation and Development, Recommendation of the Council on Artificial Intelligence) (Hrytsenchuk et al., 2024).

One of the most well-known AIsystems popular among students is ChatGPT, which significantly accelerates the search for information and resources on a particular topic, assists in formatting bibliographic references, enables the identification of unexplored or underexplored aspects, improves translation, summarizes lectures and study materials, and promotes the development of critical thinking and problem-solving skills (Zhai, 2023).

At the same time, not all learners and educational institutions have equal access to technologies that use AI. This may increase inequality in education. Inequality in access to technologies and the use of AIin education represents a serious ethical problem that may increase inequality in the educational environment. This issue is represented by a number of challenges related to access to equipment and the internet, availability of educational programs and resources, technological literacy, cultural and language barriers, and the level of support from teachers and administrators. In addition, not all learners have the same level of technological literacy and skills required to use artificial intelligence. In such cases, some learners may experience a lack of competitiveness and opportunities (Hladkykh & Sharova, 2020).

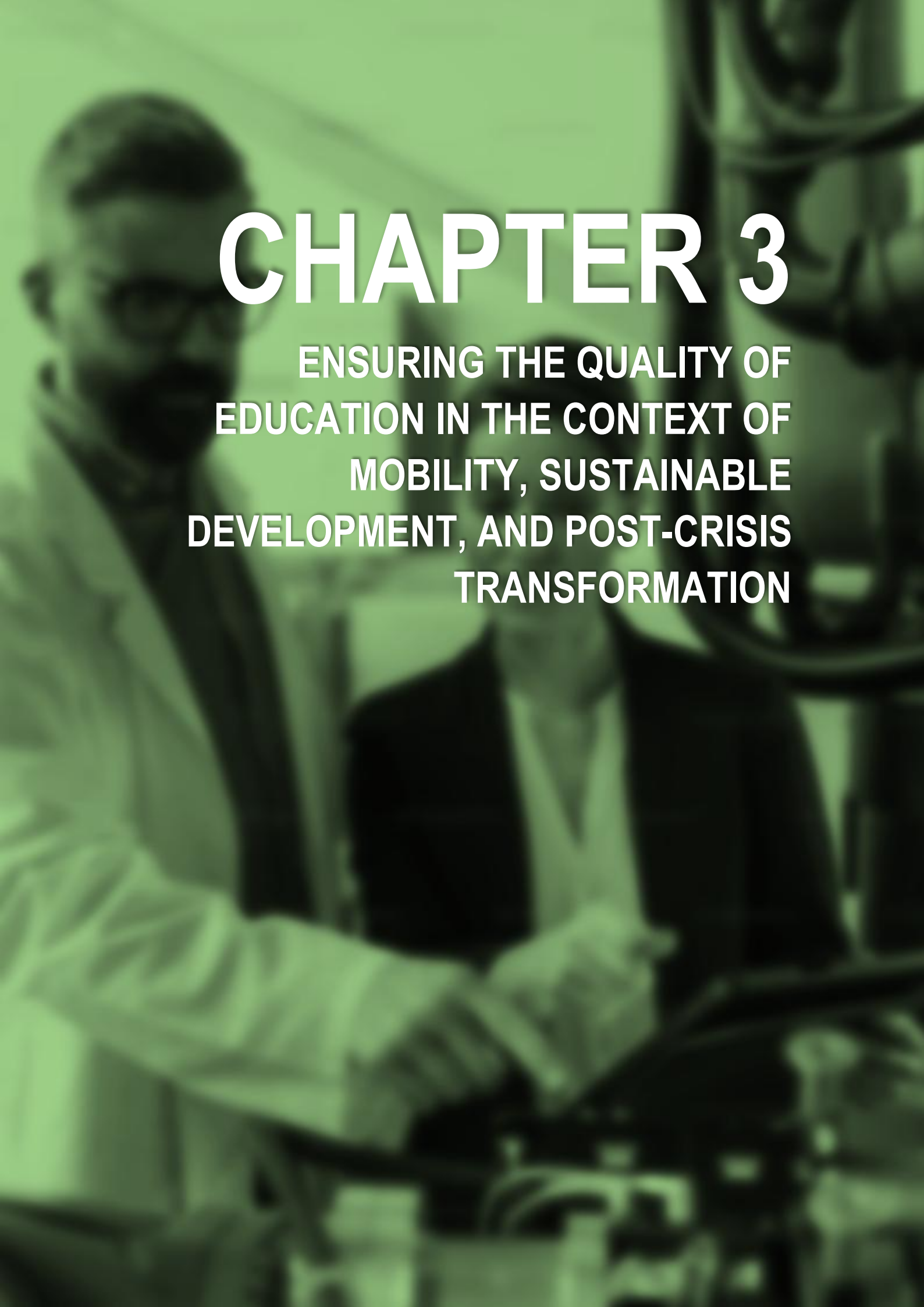
Also, ethical aspects of using AI technologies in education include ensuring data confidentiality, preventing discrimination, and maintaining algorithm transparency. It is also necessary to consider risks associated with dependence on these technologies, possible loss of social interaction in learning, and issues of academic integrity (UNESCO, n.d.).

AI may underestimate important aspects of learning such as emotional support and motivation provided by teachers and other human factors. The absence of the human factor in the use of AIin education is one of the key problems arising during the automation or development of automated learning systems: emotional support and motivation, interpretation and contextualization, creativity and innovation, ethical decision-making and judgment, as well as social interaction and communication. AI may be unable to provide emotional support to learners or stimulate their motivation. For

example, it may be unable to detect learners' emotional signals and adapt learning materials according to their mood. AImay be limited in its ability to interpret and contextualize information, which may lead to unfair or incomplete assessment of learners (Sydorenko, 2016).

Dependence on the use of AI technologies in education is one of the important problems arising in the context of their use to improve the learning process: inequality of access, dependence on infrastructure, dependence on continuous technology updates, risk of technological failures, and loss of human contact. Dependence on AI technologies may deepen inequality in access to education. Learners with limited access to AI technologies or the internet may fall behind in learning compared to those who have access to modern resources. The use of AI in education requires appropriate infrastructure, including access to computers, the Internet, software, and technical support. Lack of these resources may become an obstacle to implementing AIin vocational education institutions and other educational institutions. AI technologies are rapidly developing, and their effective use requires constant updating of hardware, software, and staff competencies. This may require significant time and resource investments. In addition, the implementation of AI technologies requires training teaching staff to work with these technologies and understanding their impact on learning (Sharova & Tykhonenko, 2023).

Thus, modern scientific and technological development necessitates the modernization of vocational education through the active implementation of digital technologies, particularly AI, which is identified as a priority within the Europe 2020 strategy. AI contributes to the personalization of learning, automation of routine processes, improvement of teachers' efficiency, and enhancement of specialist training quality, particularly through the use of tools such as ChatGPT. At the same time, its implementation requires consideration of ethical aspects, ensuring academic integrity, and preserving the humanistic component of the educational process. With a scientifically grounded and responsible approach, AI can become a key factor in improving the quality and competitiveness of vocational education.



CHAPTER 3

ENSURING THE QUALITY OF EDUCATION IN THE CONTEXT OF MOBILITY, SUSTAINABLE DEVELOPMENT, AND POST-CRISIS TRANSFORMATION

3.1. RECOGNITION OF STUDENTS' LEARNING OUTCOMES IN THE CONTEXT OF TRANSNATIONAL MOBILITY

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This section examines the recognition of learning outcomes in the context of transnational mobility, with particular attention to Ukrainian children affected by forced migration. The evolution from input-based to outcome-based approaches has shifted the focus toward competencies, actual achievements, and learner-centred pathways, ensuring comparability across educational systems. Competency-based frameworks, including EQF, ECTS, micro-credentials, and digital credentials, provide transparency, support credit transfer, and facilitate validation of formal, non-formal, and informal learning. International conventions, such as the Lisbon Recognition Convention, combined with Ukrainian legislation, establish principles of presumption of recognition, enabling access even when formal documentation is incomplete. Forced mobility highlights the need for flexible, individualized approaches, including diagnostic assessment, portfolio evaluation, and recognition of prior learning, which allow learners to integrate diverse educational experiences into coherent trajectories. Digital tools enhance verification, portability, and trust in recognized achievements. Effective recognition thus forms a multidimensional ecosystem linking quality assurance, policy, technology, and learner-centred pedagogy, supporting educational continuity, mobility, and sustainable development in vocational and professional pre-higher education contexts.

Keywords: *transnational mobility, recognition of learning outcomes, children/youth migrants from Ukraine, educational integration*

In the context of the globalization of the educational space and the intensification of transnational mobility, the concept of recognition of learning outcomes has evolved from a purely technical procedure into a fundamental principle ensuring the continuity of education. The contemporary paradigm, embedded in the documents of the European Higher Education Area (EHEA), conceptualizes learning outcomes as clear statements describing what a learner is expected to know, understand, and be able to do upon completion of an educational process (Lokshyna et al., 2025, p. 11). In contrast to the traditional input-oriented approach – focused on indicators such as the number of instructional hours and course titles – modern framework approaches emphasize outputs, thereby enabling the mitigation of institutional and national disparities in the structure of educational programmes (European Commission, 2020, p. 7).

The competency-based approach constitutes the foundation for ensuring the comparability of educational outcomes. It enables the description of learners' complex cognitive and practical achievements through a system of general and specific competencies aligned with national and sectoral qualifications frameworks. As researchers note, the learning outcomes-based approach establishes a "common language" across different educational systems, which is critically important for professional pre-higher and vocational education (Bohlinger, 2017). Consequently, this makes it possible to move from the formal confirmation of diploma equivalence to the substantive recognition of individuals' actual achievements.

International recognition practices are grounded in four key pillars: transparency, trust, comparability, and fairness. Transparency is ensured through the detailed description of educational programmes and the use of instruments such as the European Credit Transfer and Accumulation System (ECTS). Trust between institutions does not emerge automatically but develops as a result of the sustained functioning of quality assurance systems. Fairness implies that any qualification or period of study obtained in one country should be recognized in another unless substantial differences can be demonstrated. These principles are embedded in the Lisbon Recognition Convention, which remains a key legal instrument in the field of academic mobility (Shah et al., 2016, pp. 2, 13–14).

The role of internal and external quality assurance in recognition procedures is of particular importance. Without a reliable quality monitoring system, learning outcomes lose their validity in the eyes of international partners and employers. Quality assurance acts as a guarantee that the declared competencies have indeed been developed by the learner and that the assessment procedure was objective (Hou et al., 2016). In the context of transnational mobility, the accreditation of educational programmes in accordance with international standards (ESG, Environmental, Social, Governance) becomes a basis for the automatic or simplified recognition of learning outcomes (Kohler, 2003).

Theoretical justification of recognition encompasses an understanding of flexible learning pathways. In the context of contemporary challenges such as digitalization and forced migration, recognition mechanisms must cover not only formal but also non-formal and informal education. This requires the implementation of micro-credentials and digital certificates, which enable the decomposition of large qualifications into discrete modules subject to rapid verification (Chakroun & Keevy, 2018, pp. 10, 19).

The integration of professional pre-higher education into the international context requires educational institutions to rethink the methodology for designing educational programmes. It is necessary to move away from rigid content replication toward the flexible modelling of learning outcomes that correspond to the demands of the international labour market (Cedefop, 2025d, p. 18). Effective recognition of learning

outcomes in a transnational dimension is impossible without synergy between academic standards and economic needs, which is achieved through the involvement of stakeholders in the evaluation of education quality (Martínez-Rojas, 2025, pp. 3–5).

Thus, the theoretical and conceptual foundations of recognition are grounded in the transition to student-centred learning, where the primary object of assessment is not the process but the specific outcome. This creates conditions for the unhindered mobility of human capital, enhances graduates' competitiveness, and promotes the internationalization of the educational space (Knight, 2021, p. 82). In this context, quality assurance performs the function of a filter that guarantees academic integrity and the alignment of acquired knowledge with established standards on a global scale (Coates et al., 2025).

The modern architecture of the legal regulation of learning outcomes recognition is shaped at the intersection of international conventions, European policies, and national legislation, aiming to ensure the continuity of educational pathways and the mobility of learners. The key legal foundation at the European level remains the Lisbon Recognition Convention, ratified by Ukraine, which enshrines the principle of the presumption of recognition: a qualification should be recognized unless a substantial difference is demonstrated (Council of Europe, 1997, p. 6). Complementing this approach is the Global Convention on the Recognition of Qualifications concerning Higher Education, which extends the logic of mutual recognition to the global educational space (UNESCO, 2019).

For vocational, professional pre-higher, and higher education, the key instrument is the European Qualifications Framework, which functions as a "translation grid" between national qualifications systems and ensures the comparability of learning outcomes through level descriptors (European Commission, 2018). The principles of accumulation and transfer of learning outcomes are embedded in the practice of ECTS and in approaches derived from ECVET, which after 2020 have been integrated into broader outcome-based instruments for vocational education. The further development of this logic is reflected in the Council Recommendation on Micro-credentials, which legitimizes micro-credentials as a tool for flexible mobility, continuous professional development, and the individualization of educational pathways (Council of the European Union, 2022a).

The national regulatory framework of Ukraine demonstrates a consistent harmonization with European approaches to the recognition of learning outcomes. The foundational act is the Law of Ukraine "On Education" (2017), which enshrines learners' right to recognition of learning outcomes acquired through formal, non-formal, and informal education. For the sector of professional pre-higher education, the key legislation is the Law of Ukraine "On Professional Pre-Higher Education" (2019), while in the field of vocational education, the provisions of the Law of Ukraine "On Vocational

Education" (2025c) apply. An important procedural mechanism is the Order of the Ministry of Education and Science of Ukraine No. 130, which establishes the procedure for recognizing in higher and professional pre-higher education the learning outcomes acquired through non-formal and/or informal education and allows for the integration of acquired competencies into educational programs (Verkhovna Rada of Ukraine, 2022a).

The crisis conditions of recent years (the COVID-19 pandemic and the full-scale war) have highlighted the need for simplified and flexible procedures for the recognition of learning outcomes. In this context, advisory acts are of particular importance, including Resolutions of the Cabinet of Ministers of Ukraine No. 734 and No. 871, which regulate approaches to the accreditation of learning outcomes obtained in foreign educational institutions and in occupied territories, and establish the practice of recognition in the absence of a complete set of documents through competency assessment procedures (Verkhovna Rada of Ukraine, 2025a; 2025b). Furthermore, in February 2025, amendments were made to the Law of Ukraine "On Complete General Secondary Education" (Verkhovna Rada of Ukraine, 2020b), Article 6, Paragraph 6, which opened the possibility for the official recognition of learning outcomes of children acquired abroad, including in Saturday and Sunday schools, educational centers, and similar institutions. This approach aligns with the provisions of Article VII of the Lisbon Recognition Convention regarding the recognition of qualifications of refugees and displaced persons (Council of Europe, 1997, p. 9).

At the institutional level, the implementation of regulatory provisions is linked to the development of internal policies on academic mobility, credit transfer regulations, and procedures for validating learning outcomes. The use of European Higher Education Area instruments – such as the Learning Agreement and the Diploma Supplement – ensures transparency and automation of credit transfer procedures (European Commission, 2025b). In professional pre-higher education institutions, the application of credit-modular logic facilitates the standardization of learning outcome descriptions, whereas in vocational education, the key challenge remains aligning modular learning outcomes with professional standards and employer needs (Kalenskyi et al., 2018, pp. 245–246).

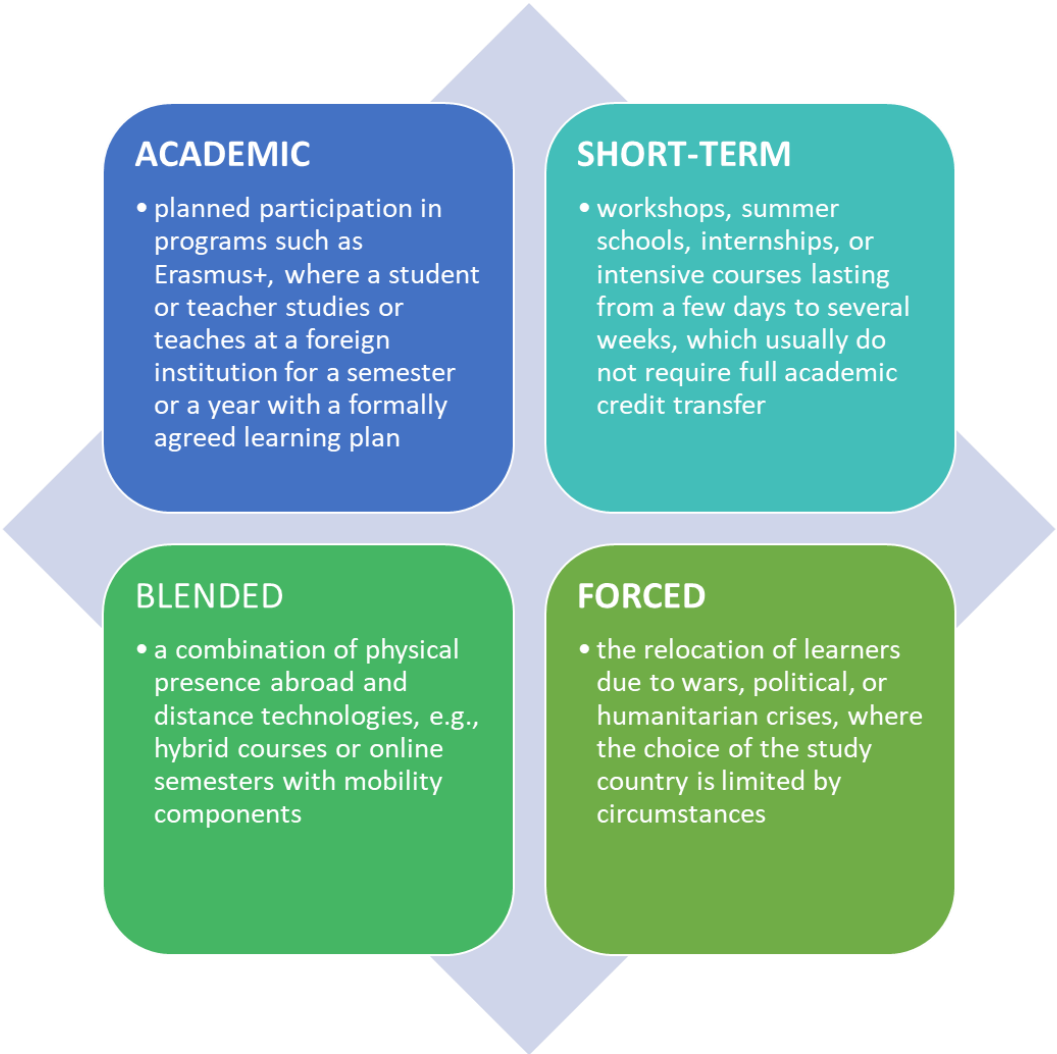
The national qualifications framework, approved by the Resolution of the Cabinet of Ministers of Ukraine No. 1341 (National Qualifications Framework, as updated in 2020), plays a systemic role in ensuring the comparability of qualifications. It aligns the Ukrainian qualifications system with the EQF and provides a basis for the recognition of learning outcomes in the context of both domestic and international mobility (Verkhovna Rada of Ukraine, 2011a).

The effectiveness of recognition mechanisms is directly linked to the digital transformation of the educational infrastructure. The use of digital achievement documentation services, in particular Europass (2026), as well as the integration of

national educational registries (notably the EDEBO system) with European systems, ensures data verification and simplifies procedures for academic and professional recognition. Current education policy shows a trend toward shifting from a formal-documentary approach to a competency-based approach, which prioritizes actual learning outcomes, their evidence, and the possibility of independent validation.

Educational mobility in the modern world is no longer exclusively a voluntary tool of academic exchange, having evolved into a complex, multi-directional phenomenon. In the context of transnational interaction, several key types of mobility are distinguished (Figure 3.1).

Figure 3.1. Types of mobility in the context of transnational interaction



Forced mobility has become a defining issue for Ukraine, where the mass displacement of learners abroad has highlighted the need for the immediate recognition of learning outcomes acquired in different jurisdictions. Each type of mobility requires specific approaches to the verification of learning outcomes, ranging from standard learning agreements to complex assessment and validation procedures.

One of the main barriers to seamless recognition is the issue of program comparability. Differences often arise in the content of modules and assessment methods. Divergent approaches to credit allocation (for example, discrepancies between national contact hours and ECTS) create situations where formally similar courses exhibit significant differences in achieved learning outcomes. This requires institutions to shift from "subject-based" comparisons to the evaluation of outcomes at the level of final competencies, which is a considerably more flexible mechanism in a transnational context (Teichler, 2017, pp. 3–10).

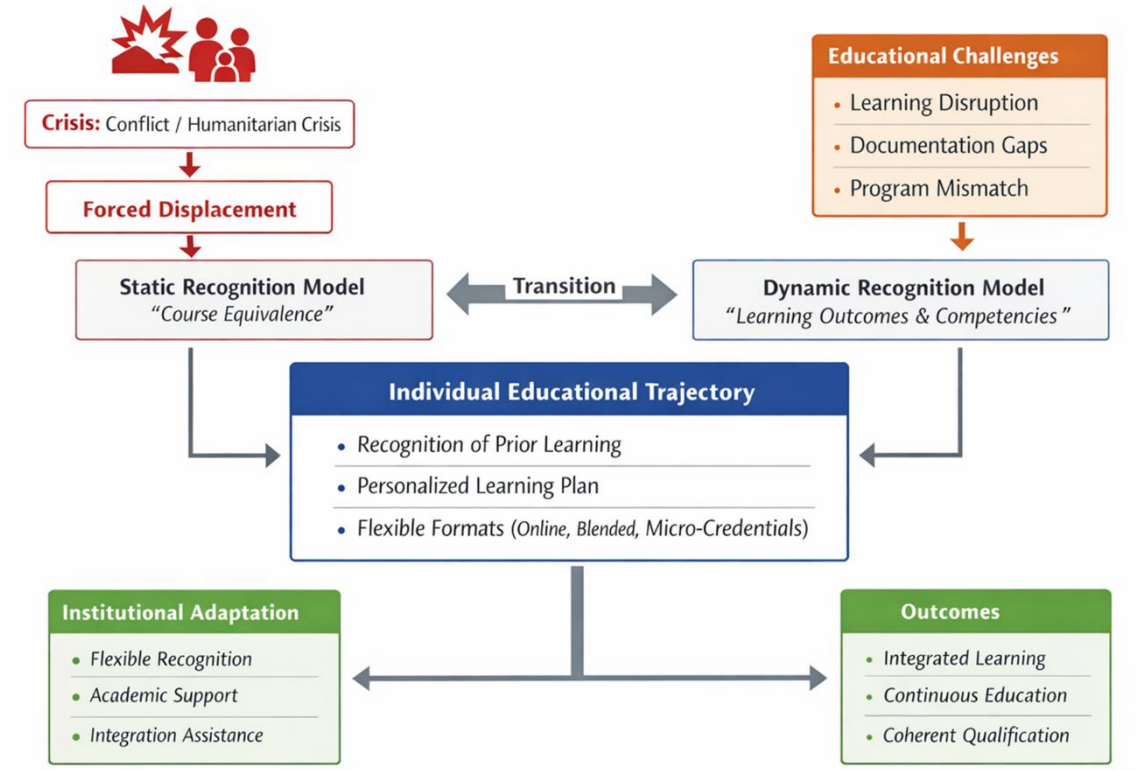
The digitalization of documentation is becoming a key facilitator of this process. The implementation of digital diplomas, micro-credentials, and blockchain technologies for certificate verification minimizes the risk of forgery and accelerates recognition procedures. The use of Europass Digital Credentials tools allows learners to accumulate verified achievements in a single digital profile, which is comprehensible to employers and educational institutions worldwide (European Commission, 2021). This is particularly important in vocational education, where the rapid verification of a specific skill can be more valuable than a full qualification.

Finally, partner networks and inter-institutional collaboration play a decisive role in ensuring the quality of mobility. Trust, which underlies recognition, is built on long-term relationships between educational institutions. The creation of consortia and the signing of bilateral memoranda allow institutions to pre-agree on quality standards, making the recognition of learning outcomes almost automatic for mobility participants. In such networks, institutions act not as competitors but as partners, jointly shaping an educational space where the interests of learners and their right to continuous education are prioritized. Thus, mobility functions not merely as physical relocation, but as a catalyst for the modernization of quality assurance procedures and the internationalization of educational programs (Beelen & Jones, 2015, pp. 62–63, 70).

Forced transnational mobility caused by armed conflicts or other crises requires a shift from static recognition models to dynamic tools that focus on the individualization of the educational process. The construction of individualized educational pathways becomes a foundational model, allowing learners to integrate learning outcomes acquired

in different institutions and countries into a coherent qualification. In situations of forced displacement, an individual pathway ceases to be merely a "course selection" and becomes a survival mechanism within the educational space, where the receiving institution must adapt its requirements to the learner's existing body of knowledge (Figure 3.2).

Figure 3.2. Individual educational trajectory in context of forced transnational mobility



One of the most effective tools for validating knowledge under such conditions is a portfolio of learning outcomes. It serves as an alternative to missing official documents, allowing learners to present not only formal grades but also examples of work, projects, and descriptions of acquired practical experience. The portfolio (Evidence of Learning) enables the assessment of "soft skills" and non-formal education, which often remain outside the scope of traditional academic transcripts (Cedefop, 2022, pp. 88–90). For vocational and professional pre-higher education institutions, this tool is indispensable when evaluating practical training, where actual skills take precedence over theoretical hours.

Digitalization has significantly transformed verification procedures through digital educational records and digital badges. Digital badges are digital indicators of achievements that contain embedded metadata about who issued the certificate, for which specific outcomes, and by what assessment methods. This ensures a high level of transparency and protection against forgery. Moreover, digital records allow a large educational program to be "fragmented" into smaller, verified parts, which is especially important during short-term mobility periods. Alongside digital records, the concept of micro-credentials is developing. They serve as a tool for flexible recognition, allowing learners to obtain official validation of learning outcomes for a single module or short course. Micro-credentials are ideally suited for conditions of forced mobility, as they enable the rapid validation of relevant skills and their integration into the labor market of the host country or their crediting as part of the main program upon return (Hurzhii et al., 2025a, pp. 32–35).

The effectiveness of all the aforementioned tools depends on mechanisms of mutual recognition between educational institutions in different countries. The creation of transnational trust networks allows institutions to delegate part of the assessment authority to one another. "Automatic recognition" models are based on shared quality standards and regular monitoring of learning outcomes (Nuffic, 2020, pp. 5–7). In vocational and professional pre-higher education, such mechanisms are often implemented through sectoral consortia, where employers and educational institutions jointly recognize the value of specific learning modules regardless of the country of origin (Radkevych et al., 2023a, p. 195). Thus, the combination of technological solutions and inter-institutional trust forms a new recognition ecosystem focused on the continuous development of individuals in the face of global challenges.

3.2. PROFESSIONAL AND PRACTICAL TRAINING OF SPECIALISTS IN ENERGY-EFFICIENT CONSTRUCTION IN QUALITY ASSURANCE OF VOCATIONAL EDUCATION

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The chapter providesa theoretical and methodological analysis of education for sustainable development as a conceptual platform for modernizing the professional and practical training of specialists in energy-efficient construction. It has been substantiated that the transformation of the construction industry within the framework of the "green" economy and the post-war reconstruction of Ukraine requires integrating environmental, economic, and social components into the content of vocational education. The potential of competency-based, systemic, activity-oriented, and interdisciplinary approaches for developing the professional readiness of future specialists capable of implementing the principles of energy efficiency and resource conservation in practical activities has been demonstrated. The role of the dual form of vocational education, the digitalization of the educational process, and partnerships with employers as strategic factors in quality assurance of vocational education has been analyzed. The directions for modernizing educational programs, developing training and practical centers, updating the material and technical base, and improving the qualifications of teaching staff in accordance with European standards have been outlined. It has been proven that professional and practical training serves as an integrative link between the education system, the production environment, and the strategic goals of sustainable development, ensuring the readiness of competitive specialists for the reconstruction of Ukraine in line with the principles of energy efficiency.

Keywords: *education for sustainable development; professional and practical training; energy-efficient construction; competency-based approach; dual education; digitalization of education; quality assurance of vocational education*

Global trends in the transformation of the energy sector of the economy and the consistent implementation of sustainable development policies are driving systemic changes in the structure of social production and a profound transformation of the content of vocational education, particularly in the field of construction. The construction industry remains one of the largest consumers of energy resources and a significant source of greenhouse gas emissions, which determines its strategic role in achieving climate goals and ensuring the energy security of the state. Under these conditions, not only the technological base of the industry is being transformed, but also the content of vocational

education, which must ensure the training of specialists capable of implementing the principles of energy efficiency, resource conservation, and environmental responsibility in practical activities. In this context, the training of specialists in energy-efficient construction acquires not only professional but also pronounced socio-economic significance.

By the Resolution of the Cabinet of Ministers of Ukraine dated April 21, 2023, No. 373-r, the Energy Strategy of Ukraine until 2050 was approved. This document defines the long-term trajectory of the country's energy development in the context of the global energy transition and integration into the European economic space. It reflects the objectives of the European Green Deal and is based on the principles of a comprehensive approach to the formation and implementation of sustainable development policies for Ukraine's economy, including the energy sector. The goals set in the Strategy will be achieved through the development of modern and safe nuclear generation, renewable energy sources, and the modernization and automation of transmission and distribution systems. Particular emphasis is placed on improving energy efficiency as a systemic factor of economic competitiveness and national energy security. One of the main tasks of the Energy Strategy of Ukraine is the fulfillment of international commitments regarding energy efficiency (Ministry of Energy of Ukraine, 2023). In this context, the training of qualified personnel is considered a prerequisite for the realization of strategic objectives, since human capital ensures the practical implementation of innovative technologies in the construction and energy sectors. Thus, the issue of forming energy-efficient competence among future skilled workers in various sectors of the economy becomes particularly relevant for the post-war "green" reconstruction of Ukraine.

The implementation of strategic guidelines requires appropriate regulatory and institutional support. The National Recovery Plan (The Cabinet of Ministers of Ukraine, 2023) and the commitments arising from integration into the European Union serve as powerful drivers of reform. These documents shape the regulatory environment within which vocational education must be transformed in response to new economic and technological challenges. They define a dual vector of development: the restoration of damaged infrastructure and the modernization of the vocational education system in accordance with European standards. Therefore, the modernization of professional and practical training is not an optional direction of development but a strategic necessity in the context of post-war reconstruction.

At the same time, the Ukrainian system of vocational education is currently facing a number of limitations. An analysis of the current state reveals structural and content imbalances between labor market requirements and the actual capacities of educational institutions. Many institutions operate according to outdated curricula that do not reflect

modern energy efficiency requirements (Herasymyk-Chernova & Khomych, 2020). This results in a gap between the declared strategic objectives and the actual learning outcomes. At the same time, the lack of technical equipment, such as airtightness testing systems, thermal imagers, and other diagnostic tools, limits opportunities for practical training. The insufficient level of material and technical support reduces the potential for developing applied competencies and makes it impossible to simulate real production situations. In addition, teachers need to improve their qualifications to teach competencies that meet European standards. Thus, the problem of modernizing vocational training has a complex character and encompasses regulatory, content-related, technological, and personnel levels.

The actualization of the problem of vocational education quality in the context of the "green" transformation of the economy necessitates a revision of approaches to the organization of professional and practical training. Scientific studies demonstrate that the implementation of the principles of integrated energy design requires the formation of interdisciplinary competencies among future specialists and the organization of team interaction already at the stage of vocational training (Brunsgaard et al., 2014). Thus, the traditional model of training, focused primarily on narrow-profile knowledge and the reproduction of technological operations, is gradually being transformed into a model based on a comprehensive vision of the building's life cycle, beginning with concept and design and extending to operation, energy consumption monitoring, and renovation.

In a broader socio-economic context, transformational processes are confirmed by OECD analytical materials (2023), according to which the "green" economy requires flexibility from the vocational education system, modernization of educational standards, and the development of micro-qualifications related to energy efficiency, renewable energy sources, digital modeling, and resource management. Similar provisions are reflected in the documents of the European Commission on the implementation of the European Green Deal, where vocational education is considered a key instrument for shaping "green" skills for the labor market. In this context, professional and practical training functions not only as a component of the educational process but also as a strategic mechanism for ensuring the quality of vocational education, directly influencing the competitiveness of graduates and their ability to adapt to technological changes.

The European experience of "greening" vocational education demonstrates the effectiveness of integrating energy-efficient competencies into all educational components: professional-theoretical training, industrial practice, internships at enterprises, and the system of professional development for teaching staff. This approach ensures the systemic and consistent formation of professional competencies, as well as alignment between industry requirements and learning outcomes. An important condition

in this regard is the partnership of vocational education institutions with employers, the implementation of the dual form of education, and the use of modern equipment and digital tools for energy monitoring.

Therefore, the theoretical and methodological foundation of professional and practical training for specialists in energy-efficient construction is represented by competency-based, systemic, activity-oriented, and integrative approaches. Their combination ensures the formation of holistic professional readiness, which encompasses not only a set of knowledge and practical skills but also the ability for analytical thinking, interdisciplinary interaction, and decision-making that takes into account ecological and economic criteria. Under current conditions, professional and practical training must be oriented toward the formation of learning outcomes aligned with sectoral standards, the principles of sustainable development, and the needs of regional labor markets. Such a methodological framework makes it possible to consider professional and practical training as a key factor in ensuring the quality of vocational education in the context of the energy transition and the post-war reconstruction of Ukraine's economy.

In scientific research, the outlined issues find further specification at the level of defining strategic directions for the formation of energy-efficient competence. Thus, Kalenskyi (2025) substantiates that the training of future skilled workers in the construction industry should be carried out along several interrelated directions: the identification of methodological approaches, principles, and pedagogical technologies for the formation of energy-efficient competence; the modeling of pedagogical conditions for its establishment and development within the educational environment of the institution; and the design of the content and structure of energy-efficient activities of learners in the process of general vocational, professional-theoretical, and professional-practical training.

The analysis of the directions proposed by the researcher indicates the necessity of considering professional and practical training as a system-forming component of the educational process, within which the integration of theoretical knowledge and real production activities takes place. At the same time, the outlined theoretical approaches require specification at the level of content, forms, and technologies of organizing the educational process. Therefore, it is logical to move from methodological substantiation to the analysis of the practical component of training, which serves as the space for the implementation of the defined approaches. In this context, professional and practical training appears not as a separate component of the educational program but as an integrated mechanism for the formation of professional competence, within which knowledge is transformed into professional action.

Professional and practical training is a decisive factor in shaping the readiness of future specialists to perform professional functions in the field of energy-efficient construction. Its content must reflect modern technological processes, innovative materials, digital tools, and the requirements of energy legislation. This involves not only mastering technologies of insulation or the installation of engineering systems but also developing the ability to conduct energy analysis of facilities, evaluate the effectiveness of design solutions, and forecast their impact on the environment and the economics of building operation.

One of the leading directions in the modernization of practical training is the introduction of Building Information Modeling (BIM) technologies. The study by Alhamami, Petri, Rezgui and Kubicki (2020) confirms that adapted BIM training programs contribute to the formation of a systemic vision of building energy consumption, the optimization of design solutions, and the development of energy analysis skills. The use of BIM in vocational education makes it possible to integrate the technical, economic, and ecological aspects of construction into a single educational model, which corresponds to the integrative approach. Thus, the digitalization of vocational training functions not only as a technological innovation but also as a methodologically substantiated means of forming complex competencies.

Equally important is the introduction of the dual form of education and workplace learning, which implements activity-based and practice-oriented approaches. Dual education has long proven its effectiveness in many European countries, particularly in Germany, Switzerland, and Austria, and it holds significant potential for development in Ukraine. Given the economic and social challenges, especially in the construction sector, Ukraine requires flexible and effective methods of training specialists capable of addressing the pressing problems of the industry. The adaptation of dual education to Ukrainian realities will become an important step toward the modernization of vocational education and the improvement of employment opportunities for young specialists in the construction field.

The experience of European vocational education offers practical models for adaptation. Dual training systems, where theoretical learning is combined with workplace practice, demonstrate how competencies can be strengthened through practical experience (Ertelt et al., 2021). Practical training should be carried out in conditions as close as possible to real production, which corresponds to the principles of dual education and workplace learning (Clarke et al., 2020). This approach ensures the combination of classroom learning with enterprise-based practice and contributes to the formation of applied competencies necessary for performing tasks such as building insulation, installation of renewable energy systems, and conducting energy audits.

At the same time, it is important to distinguish between the formal combination of work and study and the full-fledged dual form of education. In the first case, a learner may combine study with work episodically, which does not ensure the systemic formation of competencies. In contrast, the dual system provides for a structured integration of the educational process with professional activity, a clear distribution of responsibilities between the educational institution and the employer, the presence of mentorship, and a gradual immersion into the production environment. (Holyshev, 2025, p. 28). Such a model ensures the development of professional autonomy, teamwork, responsibility, and a culture of safe work. Research indicates that the implementation of the dual system contributes to increasing the employment rate of graduates, since their training corresponds as closely as possible to the real requirements of production.

The implementation of the dual form of education offers significant advantages for all participants in the educational process, especially in such a specific and practice-oriented field as construction. Learners gain the opportunity to apply theoretical knowledge in practice, work with modern equipment and technologies, develop professional identity, and increase competitiveness in the labor market. Construction companies, in turn, become involved in shaping the content of educational programs, which ensures their relevance in accordance with technological changes. Partnerships between educational institutions and industry, as well as the creation of workshops supported by manufacturers, demonstrate how effective cooperation can contribute to the development of digital technologies and the updating of educational materials (Esangbedo et al., 2024).

The dual form of education is a promising and effective model for training specialists in the construction industry, as it ensures synergy between theoretical learning and practical experience. However, its effectiveness largely depends on regulatory support, financial backing, the preparation of mentors in enterprises, and the readiness of vocational education institutions for organizational changes.

In the context of Ukraine, the problem of modernizing vocational training for construction specialists with consideration of the energy efficiency component acquires particular relevance in the conditions of post-war reconstruction. The restoration of residential, social, and industrial infrastructure must be carried out in accordance with the principles of energy efficiency, resource conservation, and ecological feasibility. This necessitates specialists of a new type (mobile, technologically prepared, and capable of working with digital tools) who will implement innovative solutions and act in accordance with European construction standards. In this regard, the development of a domestic network of training and practice centers, the modernization of the material and technical base of vocational education institutions, and the creation of laboratories for

energy auditing, energy modeling, and testing of energy-efficient technologies acquire special significance. However, the modernization of infrastructure is only a prerequisite. The decisive condition for ensuring the quality of professional and practical training is its integration with the real production environment and the professional standards of the industry.

The main features of the modern labor market for construction specialists are flexibility and high innovative dynamics. Under such conditions, employers increasingly define requirements not so much through a list of theoretical knowledge as through the expected modes of professional activity (skills, the ability to make independent decisions, readiness to act in non-standard production situations). Thus, this refers to a specific type of educational outcomes within the vocational training system, in which knowledge serves as a necessary but insufficient condition for achieving the proper quality of professional competence (Yershova, 2025b, p. 439). Therefore, the researcher's position is consistent with the competency-based paradigm of vocational education and reinforces the argument regarding the leading role of professional and practical training in shaping a competitive specialist.

The quality of vocational education should be considered as a systemic characteristic that reflects the degree of correspondence between learning outcomes and the requirements of the labor market, industry standards, and strategic guidelines of sustainable development. In this context, professional and practical training performs the function of a mechanism for verifying the competencies formed through their testing in conditions as close as possible to production. It is practice that makes it possible to identify not only the level of professional skills formation but also the learners' ability to make technically substantiated decisions, adhere to technological discipline, work in a team, and take responsibility for the result.

Analytical materials (European Union, 2015) emphasize that effective quality assurance systems in vocational education and training involve the active participation of employers at all stages of the educational cycle: from the development of professional standards and educational programs to the assessment of learning outcomes. This approach transforms the employer from the position of an external consumer of educational services into the status of a full-fledged partner and co-subject of quality assurance. The involvement of enterprises in conducting industrial practice, joint evaluation of qualification works, updating the content of training, and the expertise of educational programs creates conditions for objective monitoring of graduates' level of professional readiness.

Professional and practical training of specialists in energy-efficient construction performs a dual function. On the one hand, it ensures the formation of applied professional competencies necessary for carrying out specific production tasks. On the

other hand, professional and practical training serves as an indicator of the effectiveness of the educational process and the efficiency of quality management in vocational education institutions. Its effectiveness is determined by the degree of integration with the production environment, the systematic nature of partnerships with employers, the relevance of training content, the level of material and technical support, and the implementation of mechanisms for external and internal evaluation.

The development of the dual form of education acquires particular importance, as it ensures the synchronization of theoretical learning with production activities. Such a model makes it possible to minimize the gap between educational outcomes and real professional requirements, increase learners' motivation, and facilitate their faster integration into the professional environment. At the same time, systematic interaction with social partners establishes shared responsibility for the quality of training and creates a foundation for the long-term development of the industry.

European experience convincingly demonstrates that practice orientation, flexibility of educational programs, and the continuous updating of training content in line with technological innovations ensure the competitiveness of graduates in the labor market. For Ukraine, in the context of large-scale infrastructure reconstruction, the implementation of energy efficiency standards in vocational education is not only an educational task but also a strategic factor of economic resilience and integration into the European space.

Thus, professional and practical training serves as an integrative link between the educational system, the production sphere, and the needs of sustainable societal development. Its quality is determined not only by the level of material and technical equipment but, above all, by the depth of partnerships with employers, the relevance of training content, and the ability of the educational system to respond promptly to technological changes. It is precisely through the modernization of professional and practical training that specialists are formed who are capable of implementing the principles of energy efficiency in practical activities and carrying out the reconstruction of the country on the basis of sustainable development.

In view of the above, it is advisable to carry out a systematic comparative analysis of approaches to professional and practical training of specialists in energy-efficient construction in the countries of the European Union and in Ukraine. Such an analysis makes it possible not only to outline differences in training models but also to identify structural elements that ensure the quality of vocational education in the context of the "green" transformation of the economy. The comparison is carried out according to the following key parameters: the training model, the organization of the practical component, the level of digitalization, quality assurance mechanisms, teacher training, infrastructure provision, and the strategic role in economic development (Table 1.1).

Table 1.1. Comparative Analysis of Approaches to the Professional and Practical Training of Specialists in Energy-Efficient Construction: The EU and Ukraine

Countries of the European Union	**Ukraine**
Training model	
Competency-based, interdisciplinary, and oriented toward the building life cycle.	A gradual transition from a traditional subject-based model to a competency-based one; requiring systematic integration of interdisciplinarity.
Practical component	
Developed dual education; compulsory workplace training; close cooperation with employers.	Active development of training and practical centers; cooperation with business is strengthening but remains fragmented.
Digitalization	
Integrating BIM as a standard of professional training; digital simulations and laboratories.	Gradual implementation of BIM in vocational education institutions; requires modernization of the material and technical base.
Quality assurance mechanisms	
Systems of internal and external quality assurance (EQAVET); involvement of employers in the development of standards.	Formation of an internal quality assurance system; integration of professional standards is ongoing.
Training of teaching staff	
Specialized professional development programs in “green” technologies.	The need for systematic professional development of teachers in energy-efficient technologies.
Infrastructure of practical training	
Energy-efficient educational campuses, demonstration buildings, and renewable energy laboratories.	Establishment of training and practical centers; modernization of workshops within the framework of national and international projects.
Strategic role in economic development	
A key element in the implementation of climate policy and decarbonization.	A strategic direction in the context of reconstruction and integration into the European educational space.

Comparative analysis demonstrates that in the countries of the European Union, professional and practical training of specialists in energy-efficient construction has a systemic character and is based on the integration of educational policy with climate and economic strategies. A distinctive feature is the clear coordination between educational institutions, employers, and state authorities, which ensures the alignment of learning outcomes with labor market needs.At the same time, the systemic nature of the European model is manifested in the coherence of regulatory frameworks, financial mechanisms for supporting vocational education, institutional partnerships, and the functioning of advanced quality assurance systems (in particular, in accordance with the principles of EQAVET). This creates a holistic educational environment in which professional and practical training is regarded as a key instrument for implementing climate and innovation policy.

In Ukraine, there is a positive dynamic in the modernization of vocational education, particularly through the establishment of training and practice centers and the updating of educational standards. However, the key challenges remain: insufficient level of digitalization; limited material and technical resources; the need for systematic professional development of teaching staff; and the necessity of deepening partnerships with employers.

Unlike the EU countries, where professional and practical training functions as a structured element of a unified ecosystem “education – labor market – climate policy”, in Ukraine the modernization process still has a predominantly project-based and phased character. This results in fragmented implementation of innovations and uneven development of vocational education institutions at the regional level. At the same time, the Ukrainian vocational education system has significant potential for integrating European experience, especially in the context of post-war reconstruction, which opens opportunities for the introduction of innovative energy-efficient solutions.

Thus, the results of the comparative analysis make it possible to consider the modernization of professional and practical training not as an isolated direction of reform, but as a component of the comprehensive transformation of the vocational education system, oriented toward ensuring quality, graduates’ competitiveness, and the strategic integration of Ukraine into the European educational and economic space.

3.3. EDUCATIONAL NEEDS AND RISKS IN TRAINING SKILLED CONSTRUCTION WORKERS WITHIN THE CONTEXT OF UKRAINE'S POST-WAR RECOVERY

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The section identifies the core principles of sustainable construction and defines their content. It outlines new expectations for construction industry professionals in the context of the sustainable development concept and the "Build Back Better" principle – a key pillar of Ukraine's post-war recovery. This principle emphasizes the creation of a qualitatively new environment based on modern standards rather than the mere restoration of destroyed objects. The article provides an overview of educational needs for training construction workers, categorized by key competencies, and explores pathways for their implementation within Ukraine. Priority areas for vocational training are defined, aiming to provide the professional knowledge and skills necessary for high-quality, energy-efficient construction with minimal environmental impact. Finally, the study examines the challenges and risks of addressing these educational needs in Ukraine's current climate and proposes strategies to overcome them.

Keywords: *sustainable construction, post-war recovery, Build Back Better, vocational training, energy efficiency, environment*

The future recovery of Ukraine following the destructive actions of the Russian Federation is fundamentally based on the approach of sustainable construction. Building for sustainable development involves the design and erection of energy-efficient structures using eco-friendly materials, which minimizes environmental impact throughout the entire life cycle of the building. This approach implements the principles of a circular economy, balancing economic efficiency, social responsibility, and environmental protection in accordance with modern EU standards. The primary goal of sustainable construction is to meet the needs of the present without compromising the ability of future generations to meet theirs (Borovyk et al., 2021, p. 51).

The key principle of Ukraine's post-war recovery – "Build Back Better" – envisages more than just repairing damage; it aims to create a qualitatively new environment based on contemporary standards that incorporate the goals and principles of sustainable development. This approach encompasses three main dimensions: environmental, economic, and social (Kisterskyi, 2023, p. 7). The environmental component signifies the reduction of emissions (decarbonization), the preservation of

biodiversity at the construction site, and the protection of ecosystems. The economic component involves the ability to evaluate a building's value through Life Cycle Costing (LCC), accounting not only for initial construction but also for substantial operational savings. The social component focuses on creating inclusive spaces (accessibility), ensuring comfort for residents, and providing safe working conditions for construction workers.

These core components of the “Build Back Better” concept define the fundamental principles of sustainable construction. These principles include the optimization of energy consumption by minimizing energy demand through insulation, passive design, and the transition to renewable sources. Furthermore, it emphasizes the conservation of resources and water by implementing water-saving systems – such as rainwater harvesting – and the rational use of building materials. Priority is given to the use of eco-friendly materials, specifically renewable (timber), recycled, or local materials with a low carbon footprint.

Waste minimization is achieved by applying circular economy principles, where materials are reused or recycled after dismantling. Additionally, the quality of the indoor environment is ensured through a healthy microclimate, natural lighting, high-quality ventilation, and the avoidance of toxic materials. Finally, the principles of durability and adaptability guarantee that buildings are designed to be easily repaired, modernized, or repurposed in the future.

In Ukraine, the implementation of these principles is coordinated through the adaptation of European standards, such as Nearly Zero-Energy Buildings (NZEB), and the advancement of green certification systems like LEED and BREEAM. These fundamental principles of sustainable construction dictate that the training of a modern construction worker can no longer be limited to basic tool proficiency. The Build Back Better (BBB) concept in Ukraine serves as the official state recovery strategy, focusing on the modernization of infrastructure using the latest standards of safety, energy efficiency, and inclusivity (Cilliers, 2023).

Consequently, the modernization of vocational training programs for the construction sector must prioritize several critical aspects. These include the integration of courses on energy-efficient design, green construction, and energy management. Furthermore, success in this field relies on close cooperation with the business community and the adoption of digital technologies in education, such as VR/AR simulations and software for analyzing building energy performance, while drawing on international expertise (Kupriyevych, 2025, p. 178).

For the construction industry, the Build Back Better concept signifies a transition from simple physical reconstruction to the creation of a qualitatively new environment based on European standards. This shift drives key transformations within the sector,

including the adoption of the circular economy, enhanced energy efficiency, digitalization, harmonization with EU regulations, and the principles of the New European Bauhaus. Each of these elements must be examined in detail to understand the necessary directions for transforming professional training.

The circular economy focuses on the recycling and reuse of construction debris, such as concrete and bricks, for new projects. As of 2026, Ukraine has already cleared over one million tons of rubble, which is being repurposed as a resource for new roads and foundations. Simultaneously, the transition to Nearly Zero-Energy Building (NZEB) standards significantly enhances energy efficiency. Although this shift increases construction costs by 10–40%, it remains critically important for the nation's future energy independence.

Digitalization, particularly through BIM (Building Information Modeling) technologies, allows for precise planning and can save up to 21% of costs during the construction phase (Demian et al., 2024). Project monitoring is facilitated through the DREAM ecosystem, ensuring transparency for international investors. This technological advancement is accompanied by harmonization with EU standards, specifically the transition to European regulations on construction products, such as Regulation 305/2011, and the certification of materials to ensure reliable quality and free export.

Furthermore, the New European Bauhaus (NEB) initiative integrates three core principles: sustainability, aesthetics, and inclusivity. Within the construction sector, the "Build Back Better" concept demands more than just manual labor; it requires a new generation of specialists. Consequently, professional training is currently undergoing a transformation across several key dimensions to meet these evolving requirements.

Mastering new technologies is a cornerstone of modern construction training in Ukraine, where workers must now move beyond traditional methods. This shift involves transitioning from paper blueprints to working with digital 3D models via BIM technologies, as well as installing advanced energy-efficient systems such as heat pumps, solar panels, and modern recuperation units. Furthermore, the emergence of 3D-printed construction – already evidenced by pioneer projects like the school in Lviv – creates a growing demand for specialized operators of construction 3D printers.

The reform of vocational education, driven by the state and international partners, is actively modernizing the learning ecosystem through several key initiatives. Modern educational and practical centers are being established within vocational schools, such as the Knauf or Siniat networks, to train dry construction specialists according to European standards. This is complemented by the expansion of dual education, where students spend 70% of their time gaining hands-on experience and earning wages at real construction sites. Additionally, short-term intensive programs lasting one to three

months have been launched to facilitate the rapid requalification of veterans and internally displaced persons (IDPs).

International certification and standards play a decisive role in this educational transformation. To work on projects funded by the EU or the World Bank, construction companies must ensure their personnel are trained in green building standards, such as BREEAM and LEED. Moreover, implementing occupational health and safety protocols aligned with EU directives is a critical requirement of the "Build Back Better" concept. This also includes specialized training in on-site waste management, focusing on the sorting and recycling of construction debris directly at the workplace. The following is a detailed overview of educational needs, categorized by the key modern competencies required of construction workers.

Technological Competencies (Hard Skills). Modern technological competencies for construction workers are transforming from basic manual labor to operating high-tech equipment and digital systems. This involves acquiring specialized knowledge and skills that enable qualified workers to build with high quality, energy efficiency, and minimal environmental impact. Key focus areas include robotics management, which entails training operators for concrete 3D printers, inspection drones, and robotic manipulators. Furthermore, workers must master energy-efficiency technologies, such as "passive house" construction, the precise installation of thermal insulation to eliminate cold bridges, and the setup of airtight window systems and air recuperation units. Additionally, renewable energy skills are becoming essential, covering the installation and maintenance of solar panels, heat pumps, and integrated smart home energy management systems. This technological shift also requires proficiency in innovative materials, including eco-friendly options like timber, hempcrete, and recycled materials, along with an understanding of their physical and chemical properties.

Environmental Competencies (Green Skills). According to the European Commission (Bianchi et al., 2022), green skills encompass the specialized knowledge and abilities aimed at reducing the negative impact of construction sites and future buildings on nature. These competencies include the professional installation of energy-efficient systems, such as solar arrays, heat pumps, and advanced ventilation with heat recovery. Achieving "passive house" standards also demands skills in airtight insulation mounting. Moreover, effective waste management is crucial, involving the on-site sorting of construction debris and knowledge of recycling methods for concrete, metal, and plastic. Water conservation skills, such as installing systems for rainwater harvesting and "greywater" reuse for industrial needs, are equally vital. Finally, environmental safety

requires a deep understanding of material toxicity (e.g., VOCs, formaldehydes) and the ability to handle them safely or replace them with non-toxic alternatives.

Economic and Management Competencies. This set of competencies includes the knowledge and skills necessary for efficient planning, financial analysis, strategic decision-making, and personnel management across all construction stages. A primary focus is placed on Lean Construction, which involves organizing the workplace to minimize waste in terms of time, materials, and effort. Furthermore, workers and supervisors must understand the baseline requirements of international certification standards such as LEED, BREEAM, or DGNB. A strong emphasis is also placed on the durability of structures and buildings; by prioritizing high-quality execution, workers extend the lifespan of constructions, thereby reducing the need for frequent repairs and lowering long-term costs.

Digital Skills in the modern construction sector involve a comprehensive transition to high-tech workflows. This includes proficiency in BIM modeling, where workers must be able to retrieve data from a Building Information Model directly on-site using tablets or Augmented Reality (AR) glasses. Furthermore, managing robotic systems has become essential, requiring skills in the maintenance and control of construction 3D printers that automatically erect building frameworks. This digital literacy is complemented by the use of cloud services, enabling real-time reporting and data exchange regarding project progress through shared digital platforms.

The evolution of Material and Tool Technologies demands a new level of technical expertise. Workers must now be skilled in handling innovative mixtures, such as low-carbon concrete, geopolymers, and composite materials. This is closely linked to the rise of modular construction, which involves assembling prefabricated blocks manufactured off-site – a process that requires extreme precision during installation. Additionally, the use of "smart tools" has become standard, including the operation of laser scanners for high-precision marking and drones for monitoring hard-to-reach areas.

Soft Skills and Safety form the foundational layer of professional competence. Critical thinking is paramount, as it grants workers the ability to make autonomous decisions when deviations from the project occur on-site. Moreover, safety auditing requires deep knowledge of contemporary occupational health and environmental safety standards, which are core requirements of modern construction protocols.

As previously noted, special emphasis in the training of construction workers must be placed on mastering digital tools and acquiring skills to manage automated systems. Robotics in construction involves the implementation of automated systems, robotic

mechanisms, and Artificial Intelligence (AI) to enhance the speed, accuracy, safety, and quality of building processes. The application of these technologies is transforming the traditional industry by introducing automation at every stage – from initial design to final interior finishing. The following sections provide an overview of the primary directions for the application of construction robotics.

The implementation of 3D printing in construction – using large-scale printers for concrete structures – significantly accelerates building processes. By employing robotic manipulators or gantry systems for layered concrete application, developers can create complex architectural forms, reduce material waste, and enhance construction speed. Similarly, automated bricklaying robots are capable of continuous operation, laying bricks much faster and with greater precision than human workers.

The integration of drones and scanning technologies allows for high-quality aerial photography, progress monitoring, and the inspection of hard-to-reach areas. For instance, robots such as Boston Dynamics' Spot perform autonomous laser scanning to create highly accurate BIM models. To support human labor, exoskeletons – wearable devices that safely enhance physical capabilities – are used to reduce fatigue and the risk of injury, proving especially effective during monotonous tasks, overhead work, or heavy lifting. Furthermore, autonomous machinery, such as excavators and bulldozers equipped with GPS and LiDAR, can perform earthworks according to a pre-set program without direct operator intervention.

Robotics also extensively covers finishing and demolition works. Specialized robots for painting, sanding, and tiling operate two to three times faster than humans while ensuring high-quality surface finishes. For hazardous tasks, robotic excavators and specialized machinery for concrete demolition and debris clearing function without a constant human presence. Additionally, automation is applied to assembly and inspection, utilizing robotic arms and platforms for erecting steel structures at heights, as well as UAVs, wheeled rovers, and robotic dogs to monitor construction sites.

The aforementioned trends in construction robotics confirm that vocational training is no longer about mastering manual tools but rather about learning to operate complex systems. Based on the capabilities of modern robotics, key training specializations can be identified. These include becoming a 3D printer operator, which involves preparing mixtures, loading digital STL files, and controlling the print head trajectory. Another vital area is drone piloting, requiring licenses for UAV operation in photogrammetry and laser scanning (with courses from companies like DroneUA being particularly relevant). Finally, specialists must master BIM data management using

software like Autodesk Revit or ArchiCAD to transmit precise coordinates directly to robots on-site, as well as mechatronics maintenance, providing the fundamental knowledge of hydraulics, sensors, and controller programming needed for rapid field repairs.

Key advantages of implementing robotic systems in the construction industry include a significant enhancement of occupational safety, as robots perform hazardous tasks at heights or in environments with structural collapse risks. High precision and quality are achieved by minimizing the human factor, ensuring ideal compliance with project specifications. Despite high initial investment costs, automation guarantees economic efficiency by reducing labor and material expenses in the long term, while the capacity for 24/7 operation substantially accelerates project delivery timelines.

In February 2026, the Kyiv National University of Construction and Architecture (KNUCA) inaugurated RoboLab – Ukraine's first specialized laboratory for construction robotics. The prospects of this field are directed toward full process automation, where machines can autonomously execute the entire construction cycle. Robotics serves as a critical tool for the Build Back Better (BBB) concept, enabling faster, safer construction with reduced waste – factors of paramount importance for Ukraine amidst labor shortages and large-scale destruction.

One of the most prominent aspects of reconstruction is 3D Construction Printing (3DCP). Instead of prolonged wall erection, a printer “prints” them within a few days, as demonstrated in Lviv during the construction of Europe’s largest primary school. This technology allows for material savings of up to 20–30% and the creation of complex, energy-efficient forms that are difficult to implement manually. The subsequent phase involves demining and site preparation, where remote-controlled machines and scanner drones become indispensable. Modern Ukrainian and foreign developments, such as the GCS-200, allow for the safe clearance of up to 3000 m2 of territory per hour, operating at distances of up to 1500 m from the operator.

LIDAR technology plays a key role in damage assessment by creating precise 3D maps of objects and detecting hidden defects. Simultaneously, automation of various trades is being implemented directly on construction sites: painting robots (e.g., Canvas) ensure flawless wall finishing, while exoskeletons assist workers in lifting heavy loads, thereby reducing injury rates. For laser scanning and progress monitoring within the DREAM system, quadruped robots such as Boston Dynamics' Spot are utilized.

Particular attention is paid to robotic demolition and recycling, which allows for the safe dismantling of structures and the reuse of up to 90% of materials. Small remote-

controlled demolition machines, such as Brokk, operate in hazardous zones inaccessible to humans, while AI-driven automated lines identify and separate concrete, metal, and brick. This approach not only accelerates debris clearance but also minimizes waste and CO_2 emissions, transforming construction rubble into resources for new roads and foundations.

Preparing qualified workers for the construction sector remains one of the most critical challenges for Ukraine's recovery in the coming years. The primary risks in meeting educational needs are linked to the demographic crisis, the misalignment of educational programs with modern requirements, and various institutional barriers. As of early 2026, the dominant challenge for the construction industry is a critical labor shortage, which has already surpassed the 30% mark. It is projected that the rapid increase in housing and infrastructure reconstruction will only widen this gap, as the demand for a skilled workforce significantly outpaces the current market supply.

The situation is further complicated by a technological gap resulting from Ukraine's full transition to European quality standards for construction products starting in 2026. There is a tangible risk that a significant portion of the workforce will not have enough time to master the skills required to work under new EU regulations and with modern materials. A separate and pressing issue is the acute shortage of specialists capable of implementing BIM technologies and operating automated management systems or robotic equipment.

Simultaneously, the educational sphere is undergoing a complex institutional transformation as vocational education institutions transition into the status of municipal non-profit enterprises. This reform carries the risk of losing experienced teaching staff due to the difficulties management faces in adapting to new market conditions. At the same time, the problem of practical training remains fragmented; despite the targeted modernization of workshops by international partners, most institutions still suffer from a lack of modern machinery and equipment.

The general context of the industry's development in 2026 is defined by demographic and security factors. The continuation of military actions remains the primary systemic risk for businesses, triggering a further drain of human capital abroad. Such conditions make long-term planning for youth training programs and the stable development of the construction sector extremely difficult.

To mitigate the identified risks, several priority areas have been established. First, the synchronization of education with market demands through Dual Education is paramount. This model allocates 30% of the curriculum to theoretical studies at colleges

and 70% to paid practical training on actual construction sites. Furthermore, public-private partnerships aim to establish specialized training centers directly within major construction firms or material manufacturing companies, such as Knauf and Henkel.

The mastery of Green and Smart Technologies represents a second critical pillar. This includes specialized training in energy modernization, focusing on the installation of heat pumps, solar panels, and advanced insulation systems. Simultaneously, the integration of BIM (Building Information Modeling) technologies is essential. As noted by BIMCommunity (n.d.), the use of digital twins by designers and site foremen allows for the minimization of technical errors and the reduction of corruption risks throughout the project lifecycle.

To address the immediate labor shortage, a strategy of Rapid Retraining (Micro-credentials) has been introduced for cases where a traditional 3–4 year degree is not feasible. This approach utilizes short-term intensive programs (3–6 months) tailored for veterans, internally displaced persons (IDPs), and career changers. Additionally, the system prioritizes the validation of informal learning, providing official certification for skills acquired through self-teaching or prior work experience abroad.

Inclusivity and psychological support are being integrated as foundational standards to ensure the needs of veterans and persons with disabilities are not ignored. This involves establishing “barrier-free” standards – such as ramps, wide passages, and tactile paving – as a mandatory basis for all construction rather than an optional add-on. Psychosocial adaptation is also being incorporated into curricula to build resilience, alongside the “feminization” of construction trades. According to Yershova (2025a), gender equality in the labor market ensures equal rights, opportunities, and significance for both women and men in all spheres of public and professional life.

Finally, Digitalization and Transparency serve as the primary safeguards against corruption and the use of substandard materials. Key measures include training specialists to operate within the Unified State Electronic System in the Construction Sector (USESCS) and implementing anti-corruption compliance. By embedding ethical standards and legal literacy into the educational process, the industry aims to foster a new generation of professionals committed to high-quality, transparent reconstruction.

The strategies mentioned above represent the priority areas for training construction workers, which is critical for rebuilding the country according to the Build Back Better (BBB) concept. This concept serves as a key principle for Ukraine's recovery, implying that we must not merely repair what was destroyed but create qualitatively new objects according to modern standards, sustainable development requirements, and the

"smart city" philosophy (Yershova & Bazhan, 2020, p. 71). It is crucial to emphasize that without the preparation of skilled "blue-collar" workers – those who directly bring construction projects to life – any green strategy will remain only on paper (Mayboroda, 2025b, p. 182).

Addressing the current educational needs of Ukraine's construction industry requires the widespread implementation of the dual education model. This approach allows for a harmonious combination of theoretical training in vocational institutions with intensive practice directly on construction sites, where modern principles of sustainable construction are already being actively applied.

Alongside formal systemic education, the creation of a network of competence centers, for example, based on energy-efficiency hubs, plays a vital role. These centers should facilitate short-term retraining courses, allowing experienced professionals to quickly master specific innovative technologies, such as the installation and maintenance of heat pumps.

A vital strategic step is the integration of international certification programs into the educational process. Implementing curricula with results recognized across the EU is becoming critically necessary in the context of Ukraine's future large-scale reconstruction. This will ensure that the qualifications of Ukrainian specialists meet the requirements of international donors and will help attract foreign investment to the industry.

Several educational and professional initiatives are already operational. At the state level, the Ministry for Communities and Territories Development conducts training on planning resilient and barrier-free cities. Public projects include the "Green Reconstruction of Ukraine" practical course for specialists aiming to implement sustainable approaches, and the "Reskilling Ukraine" project, which offers courses for construction project administrators with an emphasis on digital tools like Microsoft 365 and Project. Additionally, industry associations such as the Confederation of Builders of Ukraine (CBU) coordinate efforts between business and education to overcome labor shortages and implement new skills.

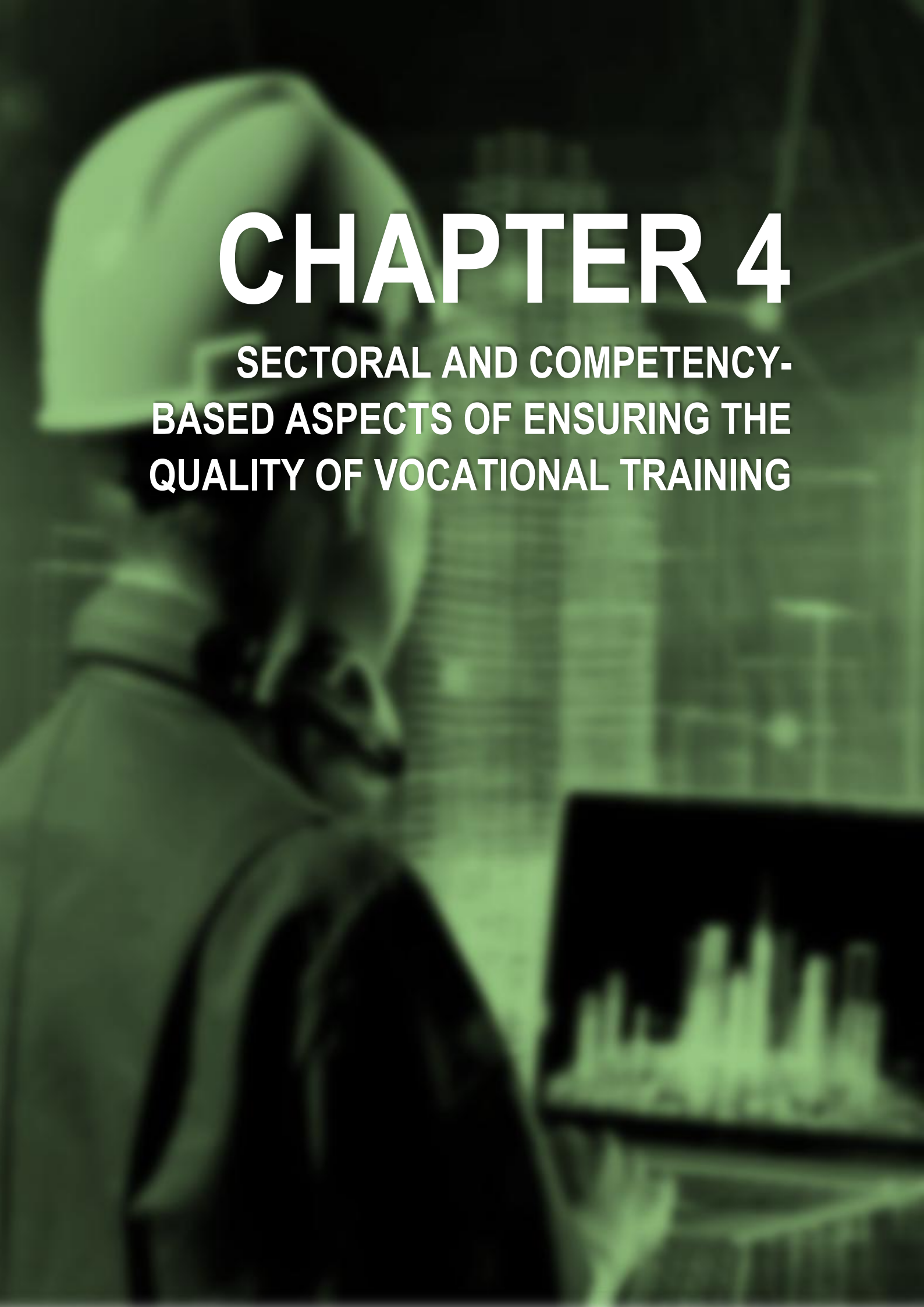
According to Kupriyevych et al. (2025), current educational opportunities for training construction workers in the context of sustainable development in Ukraine focus on integrating environmental standards, energy efficiency, and accessibility into the learning process. In the system of professional and higher education, particular attention is given to specialty 192, "Construction and Civil Engineering". Colleges and universities, such as KNUBA, are actively adapting their curricula to teach modern high-

tech skills. This includes the implementation of energy-saving technologies and eco-oriented training, which teaches future specialists methods for minimizing environmental impact and the use of eco-friendly building materials.

Additionally, specialized programs and courses allow for deeper knowledge in niche areas of sustainable development. For instance, the Schneider Electric Sustainability School offers free online courses on energy management and environmental regulations. The International Sustainability Academy (ISA) provides training for professionals on ESG factors, climate responsibility, and sustainable management. Basic sustainability programs for businesses and the general public are also available through online platforms like VUM online and UNDP resources.

A vital component is professional development and practical training aimed at inclusive reconstruction. The Ministry for Communities and Territories Development, in cooperation with the UNECE, organizes training sessions on planning barrier-free and resilient cities, which is critically necessary for modern construction. The Institute of Innovative Education at KNUBA conducts regular advanced training courses for industry specialists, while the Confederation of Builders of Ukraine, together with trade unions, offers free training in the field of construction and reconstruction, ensuring the market is supplied with personnel ready for future challenges.

Conclusions: The “Build Back Better” concept is a key principle for Ukraine's recovery, which involves not just repairing what was destroyed, but creating a qualitatively new environment based on modern standards. This concept is rooted in the fundamental principles of sustainable development and sets a range of requirements for training specialists in Ukraine's construction industry. Post-war reconstruction is a massive challenge that requires not only funding but also a fundamental change in approaches to professional training. Risks such as specialist shortages, skill gaps, and outdated technologies could critically slow down the process. The training of construction workers is no longer limited to tool proficiency; it now encompasses the integration of environmental standards, energy efficiency, and accessibility into the educational process. As the industry evolves rapidly and the demand for construction workers remains high, training occurs at multiple levels: vocational education institutions, international organizations and foundations, building material manufacturers, industry associations, NGOs, and online learning platforms.



CHAPTER 4

SECTORAL AND COMPETENCY-BASED ASPECTS OF ENSURING THE QUALITY OF VOCATIONAL TRAINING

4.1. INNOVATIVE APPROACHES TO VOCATIONAL AND PRACTICAL TRAINING OF SPECIALISTS IN THE CONSTRUCTION INDUSTRY AND THEIR ROLE IN IMPROVING THE QUALITY OF EDUCATION

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The section presents the results of a comprehensive study of transformational processes in the system of training future specialists in the construction industry. The methodological significance of immersive technologies (virtual reality and augmented reality), Building Information Modeling, dual education, and the concept of Sustainable Construction (green building) is substantiated. Based on a comparative analysis of the experience of the United States of America, Germany, and the Scandinavian countries, key determinants of successful integration of education and industry have been identified. Particular attention is paid to an in-depth psychological and pedagogical analysis, including neurodidactics, overcoming cognitive dissonance in mastering complex software, flow theory, and the formation of professional identity. The potential of artificial intelligence as a cognitive enhancer in the educational process is revealed.

Keywords: *vocational education, vocational and practical training, practical training, internship, construction industry*

The current stage of development of the construction industry of Ukraine is characterized by a complex intertwining of challenges: the necessity of large-scale reconstruction of destroyed infrastructure, integration into the European technological space, and the rapid digitalization of production processes. The traditional system of vocational education often fails to keep pace with market dynamics, which creates a gap between the theoretical background of graduates and the real requirements of employers. The quality of education today is determined not only by the volume of acquired knowledge but also by the ability of a specialist to adapt to a high-technology professional environment. The implementation of innovative approaches in vocational and practical training is a strategic task to ensure the competitiveness of domestic specialists.

The educational process must transform from passive consumption of information into active construction of professional experience through solving real cases based on the principles of Problem-Based Learning, which requires a reconsideration of the didactic foundations of vocational education. The globalization of the construction services market dictates the necessity of unifying qualification standards, where the ability to operate complex sign systems and software complexes comes to the forefront.

For a deeper substantiation of innovations in Ukraine, it is necessary to turn to the world leaders in construction education. The experience of developed countries demonstrates a clear tendency toward combining high-quality theoretical training with early industrial integration and an emphasis on technological proactivity.

The German model represents a benchmark of duality and standards (Duale Ausbildung). It is based on a rigid professional hierarchy and close cooperation between educational institutions and chambers of commerce and industry. Practical training of students is carried out in inter-company vocational training centers equipped with the most modern technology, which is updated every two to three years. A master trainer possesses not only high technical qualifications but also special psychological and pedagogical training. The psychological and pedagogical phenomenon of this model lies in the vertical transmission of experience: a learner simultaneously acts as a student in an educational institution and as a junior colleague at an enterprise. This is not merely practice, but a system of shared responsibility. The implementation of this model in Ukraine would make it possible to eliminate the gap between theory and practice through the direct participation of construction companies in financing and forming educational content.

The Scandinavian approach is associated with environmental sustainability and digitalization; education is grounded in the ethics of sustainable development. In the countries of Northern Europe (Sweden, Finland, Denmark), construction education is inseparably connected with Building Information Modeling technologies from the first year of study. Moreover, students are trained in Life Cycle Design and must be capable of calculating not only construction costs but also the costs of operation and the future disposal of a building over a period of fifty to one hundred years. This fosters strategic ecological thinking, which is critically important for the implementation of “green” reconstruction projects in Ukraine. From the first year of study, a student operates with the concept of the carbon footprint, which shapes the global responsibility of the individual – the specialist understands how his or her project will affect the ecosystem over a century.

In higher education institutions in the United States of America (for example, Purdue University or Georgia Tech), the concept of Integrated Project Delivery and the Design-Build approach are implemented. Practical training is focused on team interaction. Construction students work in cross-functional groups together with architects, lawyers, and economists. This simulates a real production process in which each participant is responsible for a specific component of the model. Such an approach teaches the art of compromise and the de-escalation of conflicts in a professional environment, develops soft skills, fosters an entrepreneurial understanding of the industry, and cultivates the ability to resolve conflicts of interest on a construction site. Emphasis is placed on cross-functional psychology: students learn in studio-based

environments where they share a common budget and collective responsibility for the final project outcome.

Let us consider in detail contemporary approaches to the organization of professional and practical training of specialists in the construction industry.

Immersive learning and digital simulations (VR/AR).

The essence of this approach lies in the use of virtual reality and augmented reality technologies in professional and practical training, which makes it possible to practice complex technological processes where an error under real conditions would be critical or costly. Under conditions of martial law and limited access to certain construction sites, virtual reality simulators enable students to be present inside a virtual construction site. According to research findings, immersive learning increases the level of material retention by seventy-five percent compared to traditional methods.

The scientific foundation of this approach is based on the concept of the digitalization of education developed by Bykov (2019). The author emphasizes that the creation of a high-technology environment does not merely add new tools but transforms the very structure of cognitive activity by modeling real professional situations and ensuring an "effect of presence" in the digital world. For Ukraine, this is critically important in the context of studying the specifics of assembling prefabricated buildings and modular structures. Virtual reality simulators make it possible to study each structural joint without the cost of expensive materials and without the risk of injury at the initial stages of training. This minimizes occupational injuries and allows for repeated practice of complex operations, which directly correlates with improved training quality.

Augmented reality acquires particular significance in the study of concealed works. Through tablet screens or specialized glasses, students can "see" the layout of utilities inside already constructed walls, which forms spatial understanding of complex engineering networks. Such an approach radically transforms quality control in education, since the instructor can monitor every action of the student in the virtual space, analyzing the speed of decision-making and the accuracy of compliance with technical regulations.

Construction operations such as welding, work at height, and crane operation require not only knowledge of algorithms but also muscular experience. From the perspective of neuropsychology, the brain perceives virtual reality experience as a real-life episode rather than abstract information belonging to semantic memory. Evidence of this is the fact that when working at height in a virtual reality simulator, a student demonstrates a genuine physiological response, including the release of adrenaline. This makes it possible to practice safety algorithms at the level of automated skills and to overcome psychological barriers associated with fear of complex equipment. Virtual reality technologies provide experience in a safe environment and create the possibility of "safe failure". Students can repeatedly make mistakes in virtual space and analyze their consequences, for example, the collapse of a structure due to improper installation,

without any real risks. The principle of visualization is implemented at an entirely new level, moving from passive observation to active interaction with the object.

As illustrative examples, several training situations may be presented. During the inspection of a working environment, such as a construction site, production workshop, or training laboratory, in a virtual environment for the purpose of assessing occupational safety conditions and identifying potential risks within the framework of the Virtual Safety Walk program, a student must identify ten violations on the virtual site. If the student fails to notice an open elevator shaft, the simulation visualizes the consequences of a fall. This creates "negative reinforcement" without real injuries, which constitutes an extremely effective didactic technique. During training in crane operation, a student in the simulator may allow critical load oscillation. The program visualizes the consequences of structural destruction, thereby forming a deep understanding of safety techniques through emotional intelligence. The use of augmented reality glasses such as HoloLens 2 enables a student or trainee to overlay a digital model of engineering networks onto real brickwork in a training workshop. The student can "see through the walls", understanding precisely where a channel for a cable must be cut while avoiding damage to load-bearing elements. This transforms an abstract scheme into a clearly visualized practical task.

Implementation of Building Information Modeling technologies as a tool for systemic design.

The global trend toward the implementation of Building Information Modeling technologies has become a standard within the European Union. Since Ukraine has officially approved the Concept for the Implementation of Building Information Modeling Technologies in Construction, educational programs must be synchronized with this state policy vector. Building Information Modeling is not merely a tool for three-dimensional modeling but a comprehensive methodology for managing the entire life cycle of a construction object. The transition from classical two-dimensional drafting to integrated five-dimensional modeling, in which a student's practical work consists of creating a digital twin of a building, is mandatory for contemporary professional education.

The approach предусматриеs the use of tools applied in real production environments. Specialized software must be integrated into the educational process:

1. Autodesk Revit (BIM-foundation). It holds priority in training. The program enables parametric modeling. A student does not simply draw a wall but defines its physical parameters, including thermal conductivity, density, and multilayer composition. The software automatically calculates the energy efficiency of the structural element.

2. Navisworks (for coordination and four-dimensional planning). It is used for clash detection. The program enables simulation of construction processes over time,

thereby teaching site logistics. For example, students integrate the “Architecture” and “Ventilation” sections. Navisworks identifies fifteen points of intersection between air ducts and beams. The student must independently correct the model, simulating the real work of a Building Information Modeling coordinator.

3. Fieldwire and Autodesk Construction Cloud (as field management tools). Students learn to upload drawings to a tablet device, make annotations regarding errors on a real object or its mock-up, and assign responsible executors through cloud services. This forms digital technical supervision skills.

4. Synchro 4D, a platform for visualizing the construction process over time and for visual modeling of work schedules. It allows the avoidance of equipment downtime and enables the visualization of logistical bottlenecks before construction begins.

5. Twinmotion / Lumion, platforms for real-time visualization that support the creation of immersive project presentations.

Research confirms that the use of Building Information Modeling-oriented tasks develops systemic thinking and the capacity for collaborative work among future construction specialists (Chaika and Hutnik, 2021). For example, a student changes the floor structure material from cast-in-place concrete to prefabricated slabs. The software automatically recalculates material quantities and reinforcement specifications, while the Navisworks module updates the construction schedule, demonstrating a reduction in installation time. This fosters understanding of the construction process as an integrated economic system. In another example, a student changes the concrete grade in the foundation model. The system automatically recalculates the total cost of the project and adjusts the material delivery schedule to the construction site. This provides insight into the interdependence of technical and economic parameters.

The implementation of Building Information Modeling in practical classes enhances the quality of education through interdisciplinary integration. Architects, structural engineers, and cost estimators work within a unified information environment that simulates a real design office. This makes it possible to detect clashes at the training stage, such as the intersection of a ventilation pipe with a load-bearing beam, which in real construction would result in significant financial savings. The quality of education thus transforms from formal compliance with state standards to practical readiness for the complex challenges of the digital era.

The Building Information Modeling approach in pedagogy implements the principle of learning by doing. A student perceives not an abstract line in a drawing but a physical object with a set of attribute data, including material, cost, and service life. This fosters responsibility for design decisions, since any error is instantly reflected in related sections of the project. In the context of Ukraine’s reconstruction, Building Information Modeling functions as a safeguard against inefficient use of resources; therefore, training personnel in this domain constitutes a priority of the national digitalization strategy. It

also enables the introduction of objective assessment methods, as the software automatically records errors in the model, thereby minimizing instructor subjectivity. The reconstruction of Ukraine will require transparency and accuracy in calculations to attract international investment. A specialist who does not possess competencies in Building Information Modeling and lacks skills in working within environments such as Autodesk Revit, ArchiCAD, or Tekla Structures will be unable to cooperate effectively with foreign contractors and will remain outside the contemporary labor market.

Dual education and training.

Dual education involves the integration of formal instruction within educational institutions with workplace-based training at enterprises to achieve specific professional qualifications. The methodological framework of the dual system is rooted in the German model, adapted to Ukrainian realities by Nychkalo (2014), who emphasizes the critical importance of the "state-education-business" partnership. This approach addresses the issue of "technological lag" in educational institutions by leveraging stakeholder resources. Amidst a shortage of skilled labor driven by migration processes, the dual form serves as a mechanism for the rapid professional adaptation of youth. Students gain access to advanced specialized machinery, laser scanners, and innovative construction mixtures that are often unavailable in vocational colleges or schools. This constitutes "situated learning", where the student becomes an integral part of a "community of practice". For the construction industry, this implies that up to 70% of practical training can be conducted directly on construction sites under the supervision of industrial mentors. A direct technology transfer occurs from the manufacturer to the learner, guaranteeing high-quality practical skills. For instance, a vocational institution may collaborate with a company utilizing Light Detection and Ranging (LiDAR). During field practice, a student learns to generate a "point cloud" of a damaged building, which is subsequently processed at the educational institution to create a reconstruction model. This integrates modern non-destructive testing and diagnostic methods into the curriculum.

In the dual approach, the quality of education is ensured through the market validation of skills. Enterprises are incentivized to provide high-quality training, as the student is a prospective employee. This creates a natural filter for the relevance of knowledge: obsolete theoretical components are discarded in favor of real-world technological maps and industry regulations. Such alignment is crucial for fostering a builder's "ecological responsibility", which is a direct requirement of European educational quality standards.

The socio-pedagogical dimension of duality lies in early professional socialization. The student internalizes corporate culture, professional ethics, and the hierarchy of responsibility inherent to a construction site. The educator acts as a moderator, helping the student bridge the gap between theoretical "ideals" and practical "realities", thereby fostering critical thinking. This mitigates the "graduate crisis", where

young specialists struggle to adapt to the actual pace of production. For construction companies, this is a tool for "cultivating" loyal personnel with a specific set of required competencies. In the Ukrainian context, where many construction sites also serve as objects of experimental reconstruction, the student becomes a participant in a real historical process, which significantly enhances their motivation.

STEM-integration and sustainable construction.

The practical study of energy-efficient technologies, construction waste recycling, and the implementation of alternative energy systems is becoming a mainstream component of professional training. Aligning with the European Green Deal, Ukraine requires specialists capable of designing and erecting Net-Zero or carbon-negative buildings. The unprecedented volume of construction debris resulting from large-scale destruction necessitates advanced recycling expertise. Training students in the technologies of concrete and brick recycling, as well as the integration of geothermal heating and solar panels into roofing structures, is no longer merely an innovation but a humanitarian necessity.

The cultivation of ecological responsibility in future builders is a direct requirement of international environmental management standards (ISO 14001). This shift enhances the quality of education by making it globally oriented and socially significant. The ecologization of vocational education is extensively analyzed in the works of Herliand (2025), who emphasizes the importance of the proactive nature of education for sustainable development.

Professional and practical training now encompasses laboratory research on the thermal conductivity of innovative eco-materials, calculations for building energy passports, and the study of international certification standards such as BREEAM and LEED. The STEM approach (Science, Technology, Engineering, Mathematics) enables students to comprehend the physicochemical processes underlying material properties. For instance, studying concrete carbonation or the thermal inertia of building envelopes requires a profound foundation in the natural sciences. Integrating this ecological component into practical training fosters a new professional ethic – redefining the builder not as a "conqueror of nature", but as a creator of a harmonious living environment.

Given Ukraine's current energy resource deficit, expertise in thermal modernization (retrofitting) has become the most sought-after competency in the labor market.

Gamification and digital management platforms.

The implementation of game-based methodologies (gamification) in practical training serves as a catalyst for student engagement in vocational education. Utilizing mobile applications for on-site quality control, such as Fieldwire or PlanGrid, within the educational process bridges the gap between students and the realities of digitized

management. Students learn to oversee processes through digital dashboards, aligning their competencies with "Industry 5.0" standards.

According to cognitive learning theory, game simulations activate deep-seated processes of experiential acquisition. Research by domestic scholars indicates that interactive methodologies foster the development of soft skills: communication, leadership, conflict resolution, and teamwork (Levit & Yevtukhova, 2024). For a construction professional, these are critical, as project delivery is always the result of collective interaction among numerous subcontractors. The use of mobile cloud services allows students to receive real-time feedback from an instructor acting as "technical supervision". A student uploads a photograph of the completed work, the instructor places a digital marker on an error, and the student must rectify it within the model. This mimics modern construction management workflows and differs fundamentally from traditional paper-based blueprint reviews, thereby enhancing the dynamics and quality of training.

Gamification addresses the issue of monotony in certain stages of the curriculum. Competitive elements – such as rankings, badges for budgetary precision, and difficulty levels in Virtual Reality (VR) – stimulate intrinsic motivation. In construction education, this is particularly effective when studying the regulatory framework (State Building Norms (DBN), DSTU), which is often perceived as cumbersome in traditional formats. Transforming the verification of regulatory knowledge into a digital quest increases retention rates by 40–50%. This approach is vital for overcoming formalism in education and ensuring that standards are internalized rather than merely memorized.

Modular competency-based approach based on micro-credentials.

In an era of rapid technological shifts, traditional 3-4 year educational programs often become overly inert. An innovative alternative is the implementation of a micro-credentials system, where practical training is deconstructed into short, intensive modules (e.g., "Installer of Translucent Structures", "Concrete 3D Printing Specialist", "Building Energy Auditor", or "Ventilated Facade Installer").

This approach is necessitated by the need for flexible educational trajectories (Ohiienko, 2013). Modularity allows students to independently curate their professional profiles based on the demands of regional labor markets. For Ukraine, this is particularly pertinent in the context of accelerated personnel training for the reconstruction of the housing stock. Each module concludes with a certification that meets the quality requirements of professional standards. This enables students to enter the labor market after their first year of study, equipped with a specific applied skill. Each module functions as a cycle: "Theory – Simulation – Practice – Certification", creating a "situation of success" for the learner.

To operationalize these approaches, a specialized training module, "Construction Site BIM Coordinator", is proposed for integration into the construction curriculum. The structure of this module is presented in Table 4.1. The module is built on the synergy of

BIM technologies and field management, adhering to the principles of micro-credentials. This allows the student to obtain a BIM Coordinator certificate prior to completing the main course of study, significantly enhancing their employability.

Table 4.1. Structure of the "Construction Site BIM Coordinator" Training Module

Training Stage	Activity Content (Innovative Component)	Rationale and Role in Quality Assurance
I. Analytical	Working with laser scanning data (Scan-to-BIM). Collecting point cloud data of the physical object.	Develops skills in digital documentation of the as-built state for reconstruction; ability to work with Big Data in construction.
II. Project-based	Creating 4D and 5D models for structural assembly (time + cost) using Navisworks.	Cultivates skills in digital scheduling of time and resources. Provides a holistic view of project economics and logistics.
III. Technological	Coordination of project sections, identification of geometric and logical clashes, and synchronization of utility networks in a cloud environment.	Develops analytical thinking, error prevention capabilities, and collaborative working skills in a team environment.
IV. Managerial	Utilizing AR (Augmented Reality) tools for designer supervision on-site. VR-based acceptance of completed works compared against a Digital Twin.	Transition from paper-based to real-time digital quality control. Formulates high-tech technical supervision competencies.

The implementation of such a module ensures alignment with "Industry 5.0" requirements, where the physical object is inextricably linked to its digital counterpart. This is crucial for preparing a workforce capable of managing infrastructure restoration based on the "Build Back Better" principle.

Implementation of artificial intelligence.

The integration of Artificial Intelligence represents the next milestone in enhancing the quality of vocational and practical training. AI can serve as an automated tutor and a quality controller for design solutions, performing several key functions:

- Automated Project Verification: Utilizing AI algorithms (e.g., in conjunction with Solibri Model Checker) allows for the automatic analysis of student work for compliance with State Building Norms (DBN). Students receive error reports within

seconds, enabling instructors to shift their focus from mechanical checks of wall thickness to discussing conceptual design solutions.

- Generative Design: students learn to define parameters (e.g., maximum energy efficiency at minimum cost), while AI generates hundreds of structural variations. This trains future engineers to manage Big Data and select optimal solutions based on rational criteria.
- Adaptive Learning and Personalization: AI platforms analyze a student's pace of material acquisition within the BIM environment and suggest supplementary exercises for challenging topics, such as static load calculations. AI identifies calculation errors and generates unique tasks to address specific knowledge gaps, thereby operationalizing the principle of individual educational trajectories. AI acts as a cognitive amplifier, transforming the educator's role into a creator of complex, personalized learning scenarios.

Examples of AI Prompts for educators:

Case Study Generation: “Act as a BIM management expert. Formulate a technical assignment for 4th-year students to construct a 5-story office center. Include three specific “hidden ” clashes between “HVAC ” and “Structural Concrete ” sections to be identified in Navisworks. Describe site conditions (Seismic Level 6) and a limited materials budget”.

Evaluation and Feedback: “Analyze the following sequence of construction stages drafted by a student. Identify logical errors in the technological process (e.g., window installation before completing monolithic works on the floor above) and explain the impact on quality and safety”.

Role-Playing: “Generate a role-play scenario: the student is a technical supervisor, and the AI is a contractor attempting to hide a foundation defect. The student must ask five diagnostic questions to uncover the violation”.

Ecological Reconstruction: “Create a comparative table for a 'Sustainable Construction' class. Compare traditional brick masonry with the use of Cross-Laminated Timber (CLT) based on the following parameters: carbon footprint, installation speed, thermal conductivity, and disposal costs in 40 years”.

It should also be noted that the success of implementing innovative approaches is largely determined not only by technological provision but also by a deep understanding of the psychological mechanisms involved in forming a builder's professional identity. The specifics of the industry demand a high level of spatial imagination and systems analysis. The psychological aspect of using BIM technologies lies in the transition from linear to volumetric-spatial thinking. The use of 3D modeling reduces the cognitive load on working memory, as the student no longer needs to mentally “assemble” an object from flat 2D drawings – they perceive it holistically. This liberates intellectual resources for solving creative engineering tasks.

According to Mihaly Csikszentmihalyi's concept of "Flow", the optimal state for learning is the "flow" state (total immersion in an activity). VR/AR technologies create a unique psychological environment where the student remains in an information field isolated from external stimuli, which significantly increases concentration. Pedagogically, it is crucial that the complexity of the virtual task matches the student's skill level: a task that is too simple leads to boredom, while one that is too difficult causes anxiety. Dynamic difficulty adjustment in VR serves as an ideal didactic tool.

The construction industry is a high-stress environment characterized by high responsibility. The introduction of complex software often triggers resistance and a fear of making mistakes. The pedagogical strategy should be based on the principle of "scaffolding" – temporary instructor support – while psychological preparation must include the development of stress resilience. The instructor gradually reduces the degree of assistance, allowing the student to manage the design process independently. Furthermore, psychological support for senior faculty members is vital, as digital transformation can be a source of professional anxiety for them.

Dual education allows students to navigate the "professional self-determination crisis" during their studies rather than after graduation. Digital tools ensure transparency in work results, which fosters an internal locus of control and personal responsibility. The socio-pedagogical aspect involves interaction with the workforce, where the student internalizes the unwritten rules of professional ethics and the subculture of builders.

The quality of vocational and practical training depends on the educator's ability to integrate technology into didactics. The transition to innovative teaching methods requires a transformation of the educator's personality. The instructor ceases to be the sole source of truth and becomes a facilitator – an individual who organizes a space for the independent search for solutions (Kremen, 2023). Their task is not to provide a ready-made answer but to teach the student to ask the right questions to the system, the BIM model, or the regulatory framework. Psychologically, this requires empathy and reflection from the educator. A coaching approach ("I believe you will find the solution") stimulates student autonomy and their internal locus of control – the belief that success on a construction site depends on their professionalism rather than external circumstances. In this new format, the educator must possess skills in discussion moderation and technical consulting for complex professional tasks. This necessitates continuous professional development (Life-long learning), which is also a component of educational quality. Without a "digital teacher", even the most modern equipment remains merely an expensive toy.

It is essential to consider students' psychological readiness for working in digital environments. Research indicates that despite being "digital natives", modern youth require structured methodological support when transitioning from the recreational use

of gadgets to professional application. An innovative approach involves creating a safe environment for errors in virtual spaces, where students are not afraid to experiment with structural parameters in a BIM model or VR environment. This significantly lowers the cognitive barrier to the real-world responsibility encountered on a construction site. Today, the quality of vocational and practical training is measured not by the absence of student errors, but by the ability to independently detect and rectify them using digital tools.

The implementation of innovative approaches in Ukraine's construction education is currently a matter of national security and long-term economic resilience. Post-war reconstruction will demand more than just “hands”; it will require intellectually prepared specialists capable of working with high technologies. Their comprehensive application allows for the following strategic outcomes: reduced adaptation period (graduates arrive at the workplace already familiar with software interfaces, VR safety protocols, and BIM standards); increased motivation (the use of modern devices and real-world involvement in production processes enhances the prestige of the construction profession among youth); international mobility (training based on European standards (BIM, Green Building) ensures Ukrainian specialists are competitive within the global labor market); proactivity (education begins to function ahead of the curve, preparing specialists for projects that will be implemented in 5–10 years).

Innovative vocational and practical training for the construction industry is a key condition for the successful reconstruction and European integration of Ukraine. The transition to immersive technologies (VR/AR), large-scale implementation of BIM modeling, the development of dual education, an orientation toward “Green Building” environmental standards, and the use of AI create a fundamentally new quality standard for education.

This requires not only an upgrade of the material base but also a systemic change in the mindset of pedagogical staff transition from mentorship to facilitation and coaching. Expanding cooperation with business through dual programs allows students to gain relevant experience at the forefront of technological progress, bridging the gap between theoretical models and real production requirements. Only the synergy of fundamental science, innovative education, and the real economic sector will prepare a generation of specialists capable of building a new, modern, energy-efficient, and safe Ukraine.

The psycho-pedagogical rationale for these processes proves that at the center of any technological innovation remains the human being-their capacity for life-long learning, creative inquiry, and high professional responsibility to society.

4.2. ENERGY EFFICIENCY COMPONENT OF QUALITY ASSURANCE OF PROFESSIONAL TRAINING OF CONSTRUCTION INDUSTRY SPECIALISTS

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The mechanism for ensuring the quality component of professional training of construction industry specialists in the context of its focus on energy efficiency is described. This provides an opportunity for specialists to obtain fundamental energy-efficient professional knowledge, their systematization, generalization and deepening in the aspect of energy problems; the formation of skills and abilities in energy activities necessary for the formation of energy-efficient competence. The conclusion is substantiated that the training of future construction industry specialists in vocational education institutions is aimed not only at familiarizing them with traditional skills in the design and construction of structures, but also at understanding the principles of energy-efficient construction, circular economy, and the use of environmentally friendly materials. Future specialists should be prepared not only for the use of modern building materials, but also for such technologies as Building Information Modeling in construction, design automation and energy consumption management. At the same time, formation of energy-efficient competence of specialists in the construction industry is not only relevant, but also necessary step for the implementation of strategy for the balanced development of society, which involves the rational use of natural resources, reducing energy consumption, using energy-efficient technologies in construction, as well as the formation of environmental responsibility for environmental protection.

***Keywords**: construction industry, energy-efficient technologies, quality, professional training, professional education.*

In the context of active modernization of domestic vocational education, the problem of qualitative enrichment of the educational space through the integration of modern energy-efficient technologies is becoming particularly relevant, in particular for training of construction industry specialists requires careful consideration not only of the specifics of future work related to the construction and operation of energy-efficient structures, but also of creating conditions for the comprehensive professional development of graduate of VET-schools (Haiduk et al., 2021, p. 61). In the context of training construction industry specialists, the use of energy-efficient technologies also deserves special attention, the results of which, in our opinion, can quite reasonably be

attributed to the formation of an appropriate level of their energy-efficient competence (Anishchenko et al., 2018, p. 28).

It is obvious that energy-efficient competence, being complex, multifactorial and multilevel integral formation that encompasses knowledge, skills, abilities, value orientations and personal qualities, cannot be formed spontaneously or limited to passive assimilation of mainly theoretical knowledge from individual disciplines of the construction direction, but requires systematic and comprehensive implementation of various educational classroom and extracurricular pedagogical means within the framework of holistic, interconnected and continuous educational process in VET-schools (Gerliand et al., 2025, p. 31). In order for future builder to build energy-efficiently, he must: understand the principles of heat engineering; know modern materials, insulation, facade systems; possess technologies for installing energy-saving structures; work with modern tools and equipment; correctly apply manufacturers' instructions; understand the impact of his own work on the energy efficiency of the building (Yudenkova, 2023, p. 5).

Energy efficiency today is key pillar of the European Union's energy policy, aimed at reducing its impact on the environment and climate. Ukraine should also strive for the highest standards of energy efficiency. Today, this issue is one of the priorities, since according to global estimates, Ukraine ranks second in terms of energy intensity (Denysiuk, 2013, p. 8). Energy efficiency in the modern world goes far beyond simple resource conservation, transforming into strategic imperative to ensure sustainable development and national security, acting not only as means of overcoming the energy crisis, but also as fundamental element of reducing the negative impact on the environment. This understanding of energy efficiency reflects its evolution from purely technical or economic issue to broad concept that encompasses the shared responsibility and sustainability of the state.

Analysis of international experience provides an opportunity to outline key principles and effective practices of energy-efficient and environmentally friendly construction that have been widely implemented in foreign countries. In particular:

1. Reducing energy consumption. Achieved through the implementation of thermal insulation solutions, the use of modern heating and air conditioning systems, energy-saving LED-lighting and other technologies aimed at reducing energy costs.

2. Ecologically adapted design. The impact of the building on the environment is taken into account: careful selection of the development site, preservation of the landscape and natural resources.

3. Effective thermal insulation and constructive solutions. Modern materials and technologies are used that help minimize heat loss and maintain a stable internal microclimate (Nesterova et al., 2012, p. 64).

4. Rational climate comfort systems. Installation of energy-efficient heating, ventilation and air conditioning systems that optimize energy consumption.

5. Integration of renewable energy sources. Widespread use of solar panels, wind turbines and other sources of renewable energy.

6. Rational water use. Installation of rainwater collection, purification and reuse systems helps save water resources.

7. Use of environmentally friendly materials. Preference is given to materials with a low carbon footprint, recyclable or with the possibility of further processing.

8. Integrated waste management. Strategies for reducing construction waste and its reuse are being implemented.

9. Ensuring a healthy environment. “Green” buildings are designed taking into account the comfort of users: high-quality natural lighting, ventilation, and a favorable microclimate are provided.

10. Environmental certification. To confirm compliance with the principles of sustainable development, buildings can receive international certificates, such as LEED (Leadership in Energy and Environmental Design) or BREEAM (Building Research Establishment Environmental Assessment Method) LEED and others, which certify the level of their energy efficiency and environmental friendliness.

In developed countries of the world, such as the USA, Canada, Japan, European Union, etc., energy efficiency issues in construction have been in the focus of state policy for several decades. These countries have made significant progress in developing and implementing advanced technologies, promoting the use of renewable energy sources and creating effective regulatory frameworks.

International experience also confirms the importance of renewable energy sources (RES) in the construction industry. In particular, the use of solar, wind and geothermal energy in building design has reduced dependence on traditional energy resources. Global practice in the construction industry is increasingly demonstrating the significant potential of integrating RES to ensure energy sustainability and reduce environmental impact. Various RES technologies are used at different stages of the life cycle of buildings and infrastructure facilities, offering effective solutions to cover a significant part of their energy needs.

The main trends observed at the international level are:

- passive design principles: the use of strategies that optimize building orientation, insulation, and cladding systems to maximize natural light and ventilation while minimizing heat loss;
- modern materials and technologies: the development and implementation of innovative building materials play crucial role in the energy efficiency of building, such as high-performance insulation (vacuum insulation panels provide excellent thermal efficiency, significantly reducing heating and cooling needs); electrochromic glass, which adjusts its tint depending on the intensity of sunlight, helps control solar heat and glare; green concrete (the use of recycled aggregates and alternative cement substitutes reduces the carbon footprint);
- building information modeling (BIM) allows architects and engineers to virtually model the characteristics of building before construction begins, determine potential energy efficiency, and optimize designs to achieve maximum efficiency;
- integration of renewable energy sources, such as solar photovoltaic panels and geothermal systems directly into buildings, dramatically reduces dependence on fossil fuels;
- SMART-building technologies: advanced control systems can monitor and optimize energy consumption depending on the number of people, weather conditions and other factors (intelligent thermostats, automatic lighting control, energy management systems, etc.).

As we can see, in Ukraine, energy efficiency issues in construction have begun to develop actively in recent years, especially after the signing of the Association Agreement with the European Union and the adoption of a number of legislative acts aimed at implementing European norms and standards. The introduction of energy-efficient technologies into modern construction and architectural practice in Ukraine is a multifaceted process that covers various areas of application: from the modernization of the existing housing and commercial stock to the integration of innovative solutions in new buildings and reconstruction projects.

Today, the training of future construction industry specialists in vocational education institutions is carried out on the basis of relevant standards, the structuring of the content of which is based on competency-based approach, which involves the formation and development of key and professional competencies in students. Key competencies enable an individual to understand the situation, achieve success in personal and professional life, acquire social independence and ensure effective professional and interpersonal interaction (Stopina et al., 2018, p. 6). Professional competencies determine the ability of a person, within the limits of authority, to apply special knowledge, skills and abilities, to demonstrate appropriate moral and business qualities for the proper

performance of established tasks and responsibilities, training, professional and personal development. At the same time, one of the key competencies is environmental and energy-efficient, which include knowledge: of the basics of energy efficiency; regulatory and legal acts in the field of energy conservation, ecology; methods of energy-efficient use of materials, resources, and energy-saving equipment in professional activities and everyday life; methods of energy saving at the enterprise; rules for sorting garbage, waste disposal; basics of rational use, reproduction and conservation of natural resources; methods of preserving and protecting the environment in professional activities and everyday life, as well as the ability to: rationally use energy resources, consumables in professional activities and everyday life; use energy-efficient equipment; comply with environmental standards in professional activities and everyday life.

Ecological and energy-efficient competence is formed throughout the educational program depending on the learning outcomes. The formation of energy-efficient competence in students has a number of important aspects, in particular: practical significance (most professions acquired in vocational education institutions are somehow related to energy consumption (construction, electricity, technological processes, etc.). Therefore, knowledge of the principles of energy saving is not an additional skill, but a mandatory component of professional training); formation of environmental awareness (energy-efficient behavior in everyday life is becoming the norm in many countries of the world. Raising a responsible attitude towards resources in young people contributes to the formation of a culture of sustainable development); demand in the labor market (the modern market requires specialists who not only perform technical tasks, but are also able to assess the energy efficiency of processes, offer optimization competitiveness of graduates); integration into the European educational space (the development of energy-efficient competence meets the requirements of international standards and contributes to the harmonization of Ukrainian vocational education with European educational models) (Haiduk et al., 2021, pp. 11–12).

So, it is energy-efficient competence that is an important element of the training of a modern specialist. Its formation in vocational education institutions is a strategically important step towards modernization, improving its quality and practical value, and contributes to the formation of responsible specialists capable of working in accordance with environmental standards.

For example, future specialists in the construction industry must not only possess traditional professional skills, but also have developed energy-efficient competence, which allows them to make rational technical decisions in the process of designing, constructing and modernizing buildings (Gerliand et al., 2025, p. 33). The main areas of formation of such competence include: mastering modern construction technologies,

understanding regulatory requirements, practical application of energy efficiency principles, formation of environmental and professional responsibility.

In addition, it is important to integrate interdisciplinary modules into curricula that combine knowledge of natural sciences, labor protection – this is allows you to create a holistic vision of environmental friendliness and energy efficiency as comprehensive professional skill.

The implementation of energy-efficient technologies in vocational education institutions in the construction industry covers wide range of technical solutions aimed at optimizing energy consumption and creating comfortable learning environment. One of the most common and effective areas is the thermal modernization of buildings. It includes set of measures, such as insulation of roofs, facades, installation of energy-efficient windows and doors, as well as thermal insulation of pipes. This may include replacing window structures with modern energy-efficient ones, demonstrating the practical application of these approaches, which has become part of the educational process. Heating and ventilation systems are also subject to modernization. This involves converting boiler rooms to alternative, more economical energy sources and installing modern room temperature control systems to optimize heat consumption.

The emphasis on both passive (insulation, daylighting) and active (smart systems, renewable energy sources) energy efficiency technologies reflects a comprehensive approach to the energy efficiency of buildings. This approach goes beyond simple fixes and aims for integrated, data-driven solutions. The combination of these approaches demonstrates that modern practices do not favor one approach over another, but rather advocate their synergistic integration. Such holistic strategy maximizes energy savings and operational efficiency, which, in turn, requires diverse and complex set of skills for implementation, maintenance and optimization, which directly affects the curricula and training needs for the construction industry in vocational education institutions.

Therefore, the formation of energy-saving behavior among vocational education students and staff is key. This includes simple but effective actions such as turning off the lights, unplugging electrical appliances after use (even computer that is turned off and plugged in continues to consume energy), and closing doors tightly. These seemingly insignificant habits can save impressive amounts of money on an educational institution scale per year. Increasing the culture of energy consumption is achieved through active educational work. This includes the production and placement of leaflets, stands, posters, drawings on energy-saving topics in educational institutions. The goal is to popularize the economic, environmental and social benefits of energy saving, as well as to increase the educational level of all participants in the educational process in this area. Monitoring and accounting for energy consumption is also an important aspect. Implementation of

the principle The establishment of energy consumption limits in physical terms and the transition to the application of basic level of fuel and energy consumption based on compliance with sanitary norms and rules is an important step. However, there is a need to improve the monitoring of energy consumption, as there is often a lack of accounting data, insufficient observations of weather and other factors that significantly affect the volume of consumption, as well as the lack of multi-year databases for qualitative analysis.

Behavioral and organizational changes are recognized as crucial, cost-effective components of energy efficiency, complementing technological upgrades and emphasizing the importance of the human factor in sustainable energy management. Educational programs should be aimed at developing both technical skills and important Soft-skills related to awareness, responsibility and effective energy management.

To implement these provisions, an online survey was conducted using the Google Forms web service using a specially designed questionnaire. In total, 285 teachers of various qualification categories, teaching titles and work experience from 17 regions of Ukraine and the city of Kyiv were surveyed.

By their professional experience, the respondents were distributed as follows: 46.0% − have been working in a vocational education institution for over 20 years; 12.6% −15-20 years; 11.6% − from 10 to 15 years; 11.2% − from 5 to 10 years; 18.6% − from 1 to 5 years.

The institutions that participated in the survey represented wide regional spectrum of Ukraine, most of all − Kharkiv, Kyiv, Vinnytsia, Sumy and Khmelnytskyi regions.

The responses received demonstrate that teachers are clearly aware of the key principles of energy efficiency: role of modern technologies in increasing energy efficiency (41.8%) and the importance of building insulation and modernization of heating systems (43.9%) were identified as priorities.

The most important modern technological solutions were recognized as: the use of energy-efficient equipment (47.4%), SMART-management systems (24.6%) and building automation systems (28.0%). The absolute majority of respondents support the integration of renewable energy sources into construction, primarily solar energy (62.1%).

Teachers also highly appreciated the importance of thermal insulation materials and innovative design solutions that should ensure the energy efficiency of buildings. In their opinion, the educational programs of vocational education institutions should include such topics as “Fundamentals of Energy Efficiency” (28.4%), “Methods of Increasing Energy Efficiency” (27.4%) and “Practical Skills and Cases in Energy Efficiency” (25.3%).

Most teachers (83.5%) note that their vocational education institutions teach subjects aimed at developing energy-efficient competence in students, but they mostly rate the level of knowledge and practical skills of graduates as average (over 77.5%). This indicates the need to improve the content and teaching methods.

The most effective teaching methods are identified by respondents as practical workshops (41.8%) and interactive trainings (31.2%), which indicates the need for a practice-oriented approach in developing energy-efficient skills in students. At the same time, cooperation with specialized organizations (65.6%); development of continuous training programs (12.3%); motivation to learn energy efficiency (16.8%).

Despite significant efforts by vocational education institutions, only 22.5% of teachers believe that educational programs fully meet the labor market requirements for energy efficiency, while 70.8% assess them as partially adapted. Similarly, the quality of educational materials is mostly rated as satisfactory, which confirms the need for updating resource provision.

Participation in real projects (65.3%), an increase in the number of practical classes (50.9%) and cooperation with employers are the main factors that, according to teachers, can significantly increase the motivation and effectiveness of training for vocational education applicants.

In general, the survey demonstrated a high level of awareness among teachers of the importance of energy-efficient training for future construction workers, but indicates the need for systematic updating of educational programs, increasing the practical component of vocational education, developing partnerships with business and introducing modern technologies and materials into the process of vocational training.

Analysis of the results obtained showed an average level of formation of energy-efficient competence of future construction industry specialists in four components.

The highest percentage has an average level of formation of the informational-cognitive component (77.6%), in second place is the organizational-activity component (75.4%), in third place is the personal-reflective component (75.1%), and in the last place is the motivational-value component (69.8%). Therefore, there is a need for the formation of energy-efficient competence of vocational education applicants, which should be implemented in the form of a comprehensive methodology, the gradual introduction of interdisciplinary, professionally oriented projects, a case method, etc.

The results of the study of the state of the problem of training future qualified workers in the construction industry to use energy-efficient technologies in professional activities made it possible to form the following conclusions:

- energy-efficient technologies are an integral part of the modern construction industry, and their application is considered a key factor in improving the quality of

construction and installation works, reducing energy consumption, ensuring environmental safety and competitiveness of enterprises;

- the level of integration of energy-efficient technologies into the vocational education system ranges from fragmentary to systemic, depending on the region, educational institution and the availability of a modern material and technical base. Most vocational training programs require updating the content taking into account innovative construction technologies;
- domestic educational and methodological support on the topic of energy efficiency is insufficiently didactically structured: limited number of training manuals, methodological developments and practice-oriented materials aimed at forming energy-efficient competence of future builders were identified.

Thus, the survey demonstrates high level of awareness of the importance of energy-efficient training of future construction industry specialists, but indicates: insufficient number of educational materials and equipment; lack of special training in the field of energy efficiency for proportion of teachers; fragmentation of interdisciplinary connections; limited experience of vocational education applicants in the practical application of energy-efficient technologies.

The development of energy efficiency in Ukraine will allow to compensate for the shortage of personnel engaged in the restoration of destroyed facilities, to become a stable sector of the economy and one of the types of long-term activity. We consider the implementation of innovative approaches to energy efficiency management in vocational education institutions to be particularly relevant in the context of the state policy of energy independence and Ukraine's integration into the European educational and energy space. Today, it is important not only to use modern energy saving technologies, but also to form energy-efficient competence of future specialists, which is an important component for the effective implementation of policies in the areas of energy efficiency and energy conservation.

Thus, the implementation of the energy component of professional training of construction industry specialists is impossible without taking into account modern practices of implementing energy-efficient policies in vocational education institutions, which is an important and timely step on the path to sustainable development, energy independence and modernization of the education system of modern Ukraine.

4.3. GREEN COMPETENCIES AND THEIR ROLE IN ENSURING THE QUALITY OF VOCATIONAL TRAINING FOR CONSTRUCTION INDUSTRY SPECIALISTS

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The section examines green competencies and their role in ensuring the quality of vocational training for construction industry specialists. The study investigates the legislative framework and the current state of updating professional standards within the construction sector. Particular attention is paid to the European sustainability competence framework, GreenComp, which defines a set of knowledge, skills, and attitudes conducive to a responsible approach toward ecology and health. The description of the four GreenComp competence clusters is provided: embodying sustainability values, embracing complexity in sustainability, envisioning sustainable futures, and acting for sustainability. The author substantiates the relevance of integrating "green" competencies into the vocational training system for Ukrainian construction specialists. Furthermore, the study emphasizes the necessity of a comprehensive implementation of innovative teaching forms and methods, as well as the creation of "green" learning environments to foster a new generation of professionals capable of ensuring the country's sustainable development.

Keywords: *GreenComp, sustainable development, vocational training, construction industry specialists, professional standards, green occupations, green building*

The formation of "green" competencies among construction industry specialists is driven by the necessity for a strategic transformation of Ukraine's construction sector in alignment with the principles of the European Green Deal and the concept of sustainable development.

In the current context, as the nation faces the challenges of large-scale infrastructural reconstruction, the development of human capital is of vital importance for national, environmental, and energy security. Consequently, the integration of international and national sustainable development programs into the vocational education system – specifically within the professional training of construction specialists – is a matter of paramount relevance.

The legislative framework for sustainable development in Ukraine is a dynamic structure based on the alignment of national law with European standards. The key documents include:

- The Constitution of Ukraine (Verkhovna Rada of Ukraine, 1996), which enshrines the right of individuals and citizens to an environment that is safe for life and health;
- The Association Agreement between Ukraine and the European Union (Verkhovna Rada of Ukraine, 2014), which provides the legal framework for implementing European directives on energy efficiency and environmental safety, mandating the national education system to adapt curricula to sustainable development standards;
- The Paris Agreement (Verkhovna Rada of Ukraine, 2015) on climate protection, which commits Ukraine to reducing greenhouse gas emissions in the construction sector;
- The Law of Ukraine "On Energy Efficiency of Buildings" (Verkhovna Rada of Ukraine, 2017b), establishing fundamental requirements for building energy performance, mandatory certification, and the use of energy-efficient technologies in construction and reconstruction;
- The Law of Ukraine "On Regulation of Town Planning Activity" (Verkhovna Rada of Ukraine, 2011b), which governs the planning and development of territories, including the integration of sustainable development and green building principles into the design of new facilities;
- The Law of Ukraine "On Education" (Verkhovna Rada of Ukraine, 2017a), which identifies environmental competence as a key competency for the modern individual;
- The Law of Ukraine "On the Basic Principles (Strategy) of the State Environmental Policy of Ukraine for the Period until 2030" (Verkhovna Rada of Ukraine, 2019a), providing for the "greening" of all economic sectors. The key tasks of the Law's strategic goals include the implementation of the concept of Education for Sustainable Development, the development of environmental education and upbringing, and the implementation of outreach activities aimed at fostering environmental values in society and raising the level of environmental self-awareness among citizens;
- The Decree of the President of Ukraine "On the Sustainable Development Goals of Ukraine for the Period until 2030" (President of Ukraine, 2019), ensuring the adaptation of the 17 UN Global Sustainable Development Goals into Ukrainian society;
- The Law of Ukraine "On Waste Management" (Verkhovna Rada of Ukraine, 2022b), regulating activities to prevent and reduce waste generation, mitigate the negative impacts of waste management, and promote waste reuse, recycling, and recovery;
- The Cabinet of Ministers of Ukraine Decree "On the National Energy Efficiency Action Plan for the Period until 2030" (Verkhovna Rada of Ukraine, 2021b), which emphasizes the need for training personnel capable of implementing low-energy consumption projects;

- Professional Standards approved by the National Qualifications Agency;
- National Standards for Energy Efficiency and Environmental Safety of Buildings, defining regulations and criteria for eco-friendly construction;
- State Building Norms, which are continuously updated, particularly regarding increased energy efficiency requirements;
- Green Competencies of the European Sustainability Competence Framework (GreenComp) (Bianchi et al., 2022, p. 1).

Green competencies (GreenComp) of the European sustainability competence framework were developed by the European Commission (2019) as a continuation of sustainable development ideas, which are an integral part of the European Green Deal. Its core concept lies in utilizing education to develop the necessary competencies for achieving sustainable development. GreenComp defines a set of sustainability-related competencies for integration into educational programs, aiming to foster environmental knowledge, skills, and value orientations, while promoting the development of critical thinking, empathy, responsibility, and care for the planet's condition and public health (Bianchi et al., 2022, pp. 2, 12).

This framework of “green” competencies encompasses not only theoretical awareness of environmental issues but also the capacity for strategic planning and managerial decision-making aimed at preserving the planet's ecosystem balance. Particular emphasis is placed on forming an ethic of responsible natural resource management in the interests of future generations. Furthermore, the framework highlights the necessity of implementing an environmental component into educational curricula, intended to prepare specialists and citizens capable of applying sustainable development principles in both their professional activities and daily lives.

The GreenComp framework is positioned as a universal model for lifelong learning. Its functional purpose spans several key areas:

- The Educational Sphere: integration into formal, non-formal, and informal curricula, as well as application in postgraduate education for professional development and upskilling;
- Human Resource Management (HRM): application of the competence-based approach in recruitment and the development of corporate training programs;
- The Research Sphere: conducting empirical studies on the correlation between the implementation of GreenComp frameworks and the overall effectiveness of the educational process;
- Professional Standards: modernization of qualification profiles, updating of job descriptions, and the creation of innovative professional standards that meet current environmental labor market demands (Bianchi et al., 2022, pp. 29–30).

Consequently, the vocational training of construction industry specialists, grounded in sustainable development goals, must be realized through the formation of

modern professional qualification content, the development of contemporary professional standards, the updating of existing qualification profiles, the creation of new educational standards, and the enrichment of vocational training curricula with the modern substance of green competencies (Radkevych et al., 2023b, p. 227).

The development of new professional qualifications is a complex process based on close interaction between the labor market and the education system. Amidst the transition to "green" technologies and digitalization, this process has become flexible and dynamic, allowing for a rapid response to societal changes. The foundation for specialist training is the professional standard – a document containing officially approved requirements for employee competencies, which serves as the basis for forming professional qualifications. Professional standards may be developed by employers, their organizations and associations, government bodies, research institutions, industry councils, public associations, and other stakeholders (Verkhovna Rada of Ukraine, 1971). A draft professional standard must undergo public discussion, ensuring that the perspectives of practitioners, scientists, educators, trade unions, and associations are considered. Once aligned, the document is approved by state authorities, specifically the National Qualifications Agency, granting it official status.

It is worth noting the new "green" occupations that have been established and included in the National Classifier of Ukraine DK 003 "Classifier of Occupations" and the Registry of Professional Standards: "Master of Installation and Maintenance of Renewable Energy Systems" (National Qualifications Agency, 2022); "Master of Installation, Maintenance, Repair, and Adjustment of Heat Pumps" (National Qualifications Agency, 2023); "Master of Installation of Ventilated Facades and Translucent Structures" (National Qualifications Agency, 2025).

Specifically, for the occupation "Master of Installation and Maintenance of Renewable Energy Systems", pre-service vocational training, retraining, and advanced training for specialists are already successfully implemented within Ukraine's vocational education institutions.

For the effective application of new professional standards, it is essential to understand their potential in achieving the Sustainable Development Goals of Ukraine for the period until 2030 (President of Ukraine, 2019), particularly in the context of ensuring the quality of education and creating conditions for lifelong professional development. Professional standards directly influence the quality of education by updating its content and material framework. Specifically, they serve as the foundation for developing educational standards, academic and training curricula, concepts, strategies, and methodological support. Furthermore, they facilitate the advancement of innovative educational technologies and the establishment of mechanisms for monitoring and evaluating learning outcomes, as well as for the awarding or confirmation of professional qualifications (Kravets, 2024).

The conducted analysis of professional standards and occupational profiles for construction trades (Mayboroda, 2025a) provides grounds for the following assertions: the number of professional standards for “green” occupations remains insignificant, and existing standards for construction professions do not sufficiently represent “green” competencies. Professional standards approved prior to 2023 include a list of professional and key (general) competencies that incorporate “green” elements, such as: “performing energy-saving activities”, “lifelong learning”, and “fundamentals of occupational safety and health”. However, professional standards developed between 2023 and 2025 primarily specify competencies reflecting the worker's direct professional functions, while general competencies – particularly “green” ones – are absent. This shift is due to the fact that the revised methodological recommendations for developing professional standards no longer include general competencies.

The insufficient formation of “green” competencies among construction specialists leads to a misalignment between vocational training and the dynamic requirements of the modern “green” construction environment. This significantly limits the competitiveness of vocational education graduates and creates employment barriers, as employers increasingly seek specialists capable of directly implementing environmental initiatives. One way to address this issue is the integration of GreenComp into the vocational training curricula for construction specialists (Radkevych et al., 2023b, p. 226; Bredikhina et al., 2024). Professional training must encompass issues of climate resilience, natural resource protection, and the implementation of innovative eco-technologies, with an emphasis on practical tools for sustainable resource management.

A significant scientific and practical contribution to the field of greening vocational education is the work of Haiduk, Herliand, Kalenskyi, and Piatnychuk (2022, p. 4), which provides a theoretical substantiation and practical demonstration of algorithms for the development and application of eco-oriented pedagogical technologies. The authors propose methodologies for updating the content of vocational training by integrating environmental components into the curricula for the construction industry. Furthermore, they highlight a developmental learning model focused on fostering the theoretical environmental thinking of students. A crucial achievement of this work is the adaptation of the educational process to the requirements of sustainable development by combining traditional methods with innovative eco-technologies, thereby ensuring the formation of a holistic environmental competence in future specialists.

The GreenComp concept extends beyond purely environmental aspects, encompassing spheres of social and economic responsibility, which reflects the complex nature of addressing contemporary global challenges. “Green” competencies consist of interconnected and equally significant elements categorized into four areas (Table 4.1).

Table 4.1. Structure of Sustainability Competences (GreenComp Framework)

Area	Competence	Description
1. Embodying sustainability values	1.1. Valuing sustainability	Reflecting on personal values and understanding how they align with the vision of a sustainable future.
	1.2. Supporting equity	Promoting equality and justice for present and future generations.
	1.3. Promoting nature	Recognizing the rights of other species and the need for ecosystem restoration.
2. Embracing complexity in sustainability	2.1. Systems thinking	Viewing problems from multiple perspectives, considering time, space, and interactions within systems.
	2.2. Critical thinking	Evaluating information, questioning assumptions, and recognizing the influence of social and cultural contexts on reasoning.
	2.3. Problem framing	Clearly defining sustainability challenges, identifying stakeholders, and setting problem boundaries to enable effective solutions.
3. Envisioning sustainable futures	3.1. Future literacy	Imagining alternative sustainable scenarios and identifying pathways to achieve them.
	3.2. Adaptability	Making informed decisions under conditions of uncertainty, risk, and complexity.
	3.3. Exploratory thinking	Applying creativity, experimentation, and interdisciplinary knowledge to generate innovative ideas.
4. Acting for sustainability	4.1. Political agency	Understanding political systems, assuming responsibility, and advocating for effective sustainable development policies.
	4.2. Collective action	Collaborating with others to drive change through coordination and cooperation.
	4.3. Individual initiative	Realizing personal potential and actively contributing to community and planetary well-being.

Source: Adapted from Bianchi et al. (2022, p. 2, 17–28).

The implementation of GreenComp in the vocational training of construction industry specialists should not be limited to a single educational component (subject); instead, “green” competence descriptors must be integrated across all academic

disciplines. This approach helps students understand the interconnections between environmental, social, and economic aspects. Innovative forms, methods, and tools of learning play a crucial role: author courses, online platforms, trainings, workshops, project-based learning, gamification, simulations, role-playing, professional competitions, student clubs, internships at "green" enterprises, active learning, collaborations, and field trips. Effective eco-oriented pedagogical technologies in the professional training of future builders, Piatnychuk (2024) notes information and communication technologies and technologies of problem and project learning.

Furthermore, it is essential to create "green" learning environments and ecological educational spaces, promoting eco-culture among students and staff. This includes implementing sustainable development principles directly into the institution's operations through energy-efficient lighting, waste sorting, repairing items, and eco-friendly catering. Under such conditions, future specialists develop green competencies, ecological thinking, and culture, gaining tools for the practical realization of sustainability principles and transforming their GreenComp into tangible achievements in green building and the economy.

In summary, the vocational training of construction industry specialists based on sustainable development is a critical condition for successful post-war reconstruction and the national security of Ukraine. An analysis of the regulatory framework demonstrates that Ukraine is integrating European standards into national legislation, particularly in the areas of energy efficiency and environmental safety. The GreenComp European sustainability competence framework serves as a universal tool for updating educational programs, as it encompasses not only knowledge but also value orientations and the capacity for collective action to preserve the planet.

Developing "green" competencies within the vocational training process is a vital step that requires a systemic approach. This involves not only updating educational content and revising curricula but also embedding GreenComp descriptors into professional standards and creating appropriate "green" conditions for the practical application of sustainability principles in the educational process. Systemic interaction between the state, employers, and vocational education institutions is the key to ensuring the quality of professional training for construction industry specialists.

4.4. EDUCATIONAL GOALS AND OUTCOMES OF VOCATIONAL-PRACTICAL TRAINING OF CONSTRUCTION SPECIALISTS WITHIN THE INTERNAL QUALITY ASSURANCE SYSTEM OF EDUCATION

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This section explores the educational objectives and expected outcomes of vocational-practical training for future construction specialists in the context of global risks, sustainable development, and Industry 5.0 requirements. The study emphasizes the strategic role of professional education in ensuring socio-economic resilience, infrastructure recovery, and technological adaptability. It highlights the integration of ESG principles (environment, social responsibility, governance) and the Sustainable Development Goals into the training process, focusing on ecological culture, digital literacy, social responsibility, and professional competencies such as energy efficiency, innovation, and safety standards. The research draws on the scientific contributions of the Institute of Vocational Education of the National Academy of Educational Sciences of Ukraine, which has developed eco-oriented pedagogical technologies, case-based learning approaches, and energy-efficient competence models for construction professions. The article emphasizes that professional and practical training should combine theoretical knowledge with applied skills, promoting professional independence, critical thinking, and readiness to work in the conditions of modern technological and socio-economic transformations. This approach ensures the preparation of highly qualified specialists capable of contributing to sustainable reconstruction and international integration of Ukraine's education system.

Keywords: *vocational education, construction industry, sustainable development, Industry 5.0, professional competencies, quality assurance*

Education constitutes the foundation of social progress and personal self-development, grounded in the acquisition of socially significant experience embodied in knowledge, skills, abilities, and spiritual value orientations. In defining the objectives and forecasting the outcomes of vocational and practical training for future specialists in the construction industry under conditions of acute global contradictions and contemporary challenges, it is essential to align with the urgent socio-economic needs of the country, the priorities of Industry 5.0, and the goals of the Sustainable Development Concept. This framework presupposes a balance between meeting the current needs of humanity and safeguarding the interests of future generations, particularly the universal demand for a safe and healthy environment, the maintenance of well-being, and the assurance of social justice across all spheres of human existence. The creation of conditions for the successful

advancement of Industry 5.0 and the achievement of sustainable development goals entails the social responsibility of every individual to contribute to a better future and global cultural progress, based on the principles of social justice and responsible environmental stewardship.

In recent years of the twenty-first century, global development has been marked by critical challenges triggered by kinetic wars, the deployment of economic instruments as weapons for strategic advantage, and increasing fragmentation within societies. At the same time, long-term challenges – from technological acceleration to environmental degradation – continue to generate side effects across all global ecosystems; the rules and institutions that have long sustained global stability and order are increasingly reaching dead ends or proving ineffective in managing these processes.

The Global Risks Report 2026 presents research on risks in the immediate or near-term (World Economic Forum, 2026b), the short- and medium-term (up to 2028), and the long-term (up to 2036), emphasizing that global risks are expanding in scale, interconnectedness, and speed. The core trend identified for 2026 is competition, wherein mechanisms of cooperation are collapsing, governments are retreating from multilateral structures, and stability is being undermined. Confrontation replaces collaboration, while trust – as the foundation of cooperation – loses its value. Experts note that the established world order, based on the primacy of international law, is disintegrating.

The multivector system of international interaction is under pressure, characterized by declining trust, reduced transparency and respect for the rule of law, and rising protectionism, which threatens established international relations, trade, and investment, while amplifying risks of confrontation and conflict. At the 56th World Economic Forum in Davos (3DP4ME, 2026), held under the motto “A Spirit of Dialogue”, influential leaders from various countries delivered significant speeches addressing the end of the rules-based world order. Notably, Canadian Prime Minister Mark Carney described the current reality as a “fracture of the global legal order,” stressing that a harsh reality is emerging in which the strong act as they are able, while the weak must endure what is imposed upon them (World Economic Forum, 2026a).

Among the ten greatest risks threatening humanity in the near future, global experts have identified: 1) extreme weather events; 2) loss of biodiversity and ecosystem collapse; 3) critical changes in Earth systems; 4) disinformation and misinformation; 5) adverse consequences of artificial intelligence technologies; 6) scarcity of natural resources; 7) social inequality; 8) cybersecurity threats; 9) social polarization; and 10) environmental pollution (World Economic Forum, 2026b, p. 19).

The education system serves as a powerful lever of state policy, enabling influence over the formation of intellectual and labor potential at the global, national, and societal levels. The content of educational programs and the quality of vocational and practical

training directly determine the trajectory of development and the living conditions of future generations. Training specialists in the construction industry under conditions of global risks and disruptions acquires strategic importance, given the necessity of ensuring socio-economic resilience, mitigating the consequences of climate change, war-related destruction, and economic crises, as well as addressing the urgent need for infrastructure recovery, maintenance of order, and technological adaptability.

The development of the construction sector requires the vocational education system not only to provide high-quality theoretical training but also to ensure effective organization of vocational and practical learning that fosters the competencies necessary for work in the context of contemporary technological and socio-economic transformations of Industry 5.0. The relevance of the issue of vocational and practical training for construction specialists is determined by the demand for highly qualified personnel capable of integrating technological innovations, principles of sustainable development, and occupational safety standards into production processes.

At the Institute of Vocational Education of the National Academy of Pedagogical Sciences of Ukraine, headed by Academician Radkevych, targeted scientific research has been conducted for many years on various aspects of vocational training for future specialists, particularly in the construction sector of the country. The significant scholarly contributions of the Institute's staff are reflected in works devoted to: the standardization of professional training of junior specialists in the construction industry (Luzan et al., 2020); the development and application of eco-oriented pedagogical technologies for vocational training of future skilled workers in the construction industry (Haiduk et al., 2022, pp. 29–83); the peculiarities of applying case-based technology in the vocational training of future skilled construction workers (Piatnychuk et al., 2024); and the formation of energy-efficient competence among future skilled workers in the construction industry (Herliand et al., 2025), among others.

Under the conditions of severe global challenges, the consistent adherence to the goals of the Sustainable Development Concept within the vocational education system is of paramount importance. This concept is grounded in the necessity of establishing a balance between meeting the current needs of humanity and safeguarding the interests of future generations, particularly their demand for a safe and healthy environment. The purpose of implementing the Concept is to protect the environment, ensure social justice, eliminate racial and national discrimination, and improve the standard of living of the population.

An essential prerequisite for the introduction of sustainable development principles is compliance with ESG criteria (E – environment, S – social responsibility, and G – governance), which facilitate the involvement of diverse institutions in addressing ecological, social, and governance-related challenges. The fundamental

principles of the Sustainable Development Concept provide humanity with a real opportunity to secure stable and long-term development that meets the needs of present generations while ensuring future generations the ability to satisfy their own needs.

Restrictions on the use of natural resources must be relative and determined by the level of technological progress, social organization, and the biosphere's capacity for self-renewal. It is critically important to guarantee the satisfaction of basic human needs and to create conditions for realizing aspirations toward a dignified life. Without this, sustainable development is impossible, as poverty remains one of the primary causes of ecological and social crises. Equally important is the necessity of harmonizing the lifestyles of those who consume excessive material and financial resources with the ecological capacities of the planet, particularly in the sphere of energy consumption. The pace and scale of population growth must correspond to the evolving productive potential of the global ecosystem of the Earth.

In order to safeguard Ukraine's national interests regarding the sustainable development of the state, the economy, and civil society, the Presidential Decree "On the Sustainable Development Goals of Ukraine until 2030" established the commitment to adhere to these goals throughout the designated period. According to the Decree, the Sustainable Development Goals of Ukraine until 2030 are to serve as benchmarks for the development of forecasting and programmatic documents, as well as draft regulatory and legal acts, with the aim of ensuring the balance of economic, social, and environmental dimensions of Ukraine's sustainable development (President of Ukraine, 2019).

In line with the regulatory requirements governing the organization of the educational process, the system of vocational and practical training must integrate sustainable development imperatives into the processes of national recovery and modernization. This integration is achieved through the combination of educational, practical, and institutional mechanisms that foster the formation of competencies for an innovative economy, the guarantee of social justice, and international integration.

Accordingly, vocational and practical training of future construction specialists should be oriented toward the development of professional competencies, skills, and abilities necessary for the independent execution of production tasks, the safe operation of equipment, and the enhancement of labor productivity. The main objectives of such training include:

1. Acquisition of professional skills and abilities aimed at mastering typical operations, techniques, and tools required for a specific profession at the appropriate qualification level;

2. Industrial training and adaptation, including the development of the ability to work under real production conditions, make optimal decisions, and analyze technological processes;

3. Development of professional autonomy, training in the creative application of knowledge, decision-making when working with new equipment, and diagnosing malfunctions;

4. Formation of professionally significant qualities, technical, analytical, and critical thinking;

5. Development of skills that ensure improved quality and productivity of production – effective work, reduced energy consumption, and enhanced product quality; ensuring occupational safety, studying and strictly adhering to labor protection and safety regulations, and preventing industrial violations.

The system of vocational and practical training can integrate the requirements of sustainable development into the processes of national recovery and modernization through the combination of educational, practical, and institutional mechanisms that ensure the acquisition of competencies for building an innovative economy, promoting social justice, and safeguarding environmental security. In particular, in preparing the country's human capital capable of implementing the Sustainable Development Goals in practice, relevant general and professional competencies may be formed:

1. General (basic) competencies.

- Environmental culture and resource conservation – the ability to work with technologies that minimize negative environmental impacts.
- Digital literacy – the use of modern digital tools for effective and innovative activity.
- Social responsibility – awareness of the role of professional activity in the development of society and communities.
- Legal culture – knowledge of labor legislation, human rights, and the principles of justice and transparency.

2. Socio-emotional competencies.

- Emotional intelligence – the ability to cooperate, empathize, and constructively resolve conflicts.
- Leadership and teamwork – the ability to organize collective activities and take responsibility for results.
- Inclusiveness and gender equality – readiness to work in diverse teams and respect the rights and opportunities of all individuals.

3. Professional competencies.

- Innovation and entrepreneurship – the ability to generate new ideas, create start-ups, and implement innovations in production.
- Green technologies and energy efficiency – skills in working with renewable energy sources, circular economy practices, and ecological standards.
- STEM competencies – integration of knowledge in science, technology, engineering, and mathematics to address contemporary challenges.
- International communication – proficiency in foreign languages and intercultural interaction skills for participation in global projects.

4. Strategic competencies.

- Change management – the ability to adapt to new conditions, technologies, and socio-economic challenges.
- Sustainable development as strategic thinking – integration of sustainable development principles into professional decisions and practices.
- Civic engagement – participation in social initiatives, volunteer activities, and community projects.

Within the general and professional competencies of future specialists in professions such as 7122 “Bricklayer”, 7133 “Plasterer”, 7132 “Tiler”, and 7214 “Reinforcement worker (construction, installation, and repair works)”, the approved educational standards specifically identify: communicative competence; mathematical competence; digital competence; personal, social, and learning competence; civic and legal competence; entrepreneurial competence; energy-efficient and ecological competence; and cultural competence (Ministry of Education and Science of Ukraine, 2023b; 2024c).

Among the goals and objectives of sustainable global development defined by the United Nations General Assembly in the Resolution “Transforming our world: The 2030 Agenda for Sustainable Development” (United Nations Development Programme, 2018), a central priority is the provision of inclusive and equitable quality education and the promotion of lifelong learning opportunities for all people worldwide. The tasks identified for achieving this goal include:

- Ensuring free, equitable, and quality primary and secondary education leading to desirable and effective learning outcomes;
- Guaranteeing equal opportunities for early childhood development and preschool education, preparing young children adequately for primary education;

- Promoting gender equality and accessibility to quality vocational and higher education;
- Eliminating all forms of inequality in access to education by ensuring equal opportunities for vulnerable groups, including persons with disabilities, representatives of diverse nations and ethnicities, and children in vulnerable situations, to education and vocational training;
- Developing and expanding educational institutions that address the diverse needs of learners, the specific requirements of persons with disabilities, and gender aspects, while ensuring free, effective, and safe learning environments free from violence and social barriers;
- Increasing worldwide scholarship opportunities for education, including higher and vocational education, training in information and communication technologies, technical, engineering, and research programs across different countries;
- Expanding the number of professionals equipped with in-demand competencies, including vocational skills and abilities, to facilitate successful employment, career development, and entrepreneurial activity;
- Increasing the number of qualified teachers, particularly through international cooperation in the training of pedagogical and academic staff;
- Ensuring that all learners acquire the knowledge and skills necessary to promote sustainable socio-economic development, including through the study of sustainable development and sustainable lifestyles, human rights, gender equality, the promotion of a culture of peace and security, global citizenship, and awareness of the value of cultural diversity and contributions to sustainable social progress.

International practice (European Association for Quality Assurance in Higher Education et al., 2015, pp. 9–25), among the requirements for ensuring the quality of education in a country, emphasizes the necessity of both internal and external systems of quality assurance. The internal system of quality assurance is implemented directly within educational institutions and involves the proper organization of educational management and the effective delivery of the educational process. The external system of quality assurance, in turn, provides external oversight of educational institutions, monitoring their compliance with state requirements in educational training and the effectiveness of the organization of the learning process.

At the core of the internal quality assurance system lies the institution’s policy on quality, which entails the creation and maintenance of a quality system with the involvement of all participants in the educational process and external stakeholders. Other

key components of the internal system include educational programs that must comply with state standards for specific specialties and levels of education, while also meeting learners' needs and labor market demands. The implementation of educational programs should be carried out under conditions of student-centered learning, teaching, and assessment, which aim to account for the individual characteristics, needs, and expectations of learners. Recognition of achievements, acknowledgment of students' educational outcomes, and fair assessment of their activities within the institution – taking into account results from all forms of curricular and extracurricular work, such as participation in creative competitions, sports events, and scientific research – also serve as indicators of the internal quality assurance system.

Additional important components ensuring the quality of the educational process within institutions include:

- Teaching staff, whose qualifications and professional specialization must correspond to the requirements of the educational program, and whose activities should be based on professionalism, humanistic and democratic values, innovation, and effective teaching methods;
- Learning resources and student support, which require the availability of adequate material and technical resources, such as libraries, educational equipment, and IT infrastructure, as well as comprehensive psychological and pedagogical support, including counseling, facilitation, tutoring, and mentorship;
- Information management, aimed at collecting and analyzing diverse indicators of educational activity within the institution to maintain and develop the internal quality assurance system;
- Transparency of information, meaning the clear presentation of objective and up-to-date information on publicly accessible platforms regarding the institution's activities, including the list of specialties and educational programs offered, the objectives and expected learning outcomes of these programs, admission requirements, the organization of the educational process, specific features of teaching, learning, and assessment of students' knowledge, as well as information on graduates' employment opportunities.

The effectiveness of organizing the educational process within an institution is ensured through ongoing monitoring and periodic review of programs, which involves the improvement and updating of the structure and content of educational components used in learner training, with the participation of both internal and external stakeholders. Continuous monitoring provides for the revision of program content in accordance with

the development of contemporary research in a given field, the current needs of society, and the demands of learners and employers.

The structural composition of the internal quality assurance system is completed by cyclical external quality assurance, that is, the regular implementation of external independent evaluation of the quality of educational activities by state and public bodies responsible for monitoring education quality. This process confirms the effectiveness of the internal quality assurance system and certifies the compliance of such activities with state standards and requirements.

Given that one of the priority tasks of the State Targeted Social Program for the Development of Vocational (Vocational-Technical) Education for 2022–2027 (Verkhovna Rada of Ukraine, 2021c) is the improvement of the vocational education system in line with international standards and practices, as well as current and prospective labor market needs, the key components of ensuring the quality of vocational training during this period include:

- Updating the content of vocational education, developing and approving new vocational education standards for specific professions, introducing innovative teaching technologies into the educational process, and providing learners with modern textbooks (including electronic versions);
- Implementing effective mechanisms to ensure that learners undergo industrial training and practical placements in accordance with the requirements of professional competencies and vocational standards;
- Improving career guidance for school youth and professional counseling for learners in vocational (vocational-technical) education;
- Promoting the implementation of international projects in the field of vocational education, among others.

Conclusions. Practical experience demonstrates that education is a key aspect of the global comprehensive frameworks defining the goals of sustainable development. Education serves as the foundation of all efforts related both to adaptation to ongoing changes and to the prospects of transforming the world and the environment. High-quality vocational education constitutes the necessary basis for lifelong learning in a complex and rapidly changing world. Contemporary challenges, which shape ecological, social, and governance criteria of activity, generate new requirements for educational objectives and learning outcomes.

European integration processes and the adaptation of Ukraine’s education system to the standards of the European Higher Education Area highlight the importance of

internal quality assurance, which functions as a key mechanism for enhancing the competitiveness of future specialists. The quality of education, particularly vocational education, is a crucial factor determining the progressive development of the national economy, the advancement of public welfare, the cultural sphere, and societal prosperity. Modern requirements for quality education converge around its central purpose, "Learning to Be," formulated in 1972 by a UNESCO expert group led by E. Faure in the report "Learning to Be: The World of Education Today and Tomorrow" (UNESCO, 2015). This purpose combines the personal mission of education with its orientation toward ensuring the well-being and dignified existence of humanity, both now and in the future. The right to quality education is the right to relevant, socially demanded, and substantively meaningful learning. The requirements for education quality vary across diverse cultures and communities; therefore, quality is defined by what is recognized within a given culture and society as essential for a dignified life.

Vocational and practical training of future specialists in the construction industry under current global challenges acquires strategic significance for ensuring socio-economic resilience and infrastructure recovery. The educational process must integrate the principles of sustainable development and ESG criteria, fostering ecological culture, social responsibility, and legal awareness among learners. A competency-based approach is essential, encompassing the development of general, socio-emotional, professional, and strategic competencies required for work in the context of Industry 5.0 and international integration.

The scientific and methodological achievements of the Institute of Vocational Education of the National Academy of Pedagogical Sciences of Ukraine – particularly the implementation of eco-oriented technologies, case methods, and energy-efficiency models – provide a solid foundation for the modernization of vocational education. The combination of theoretical knowledge with industrial training ensures the development of professional autonomy, critical thinking, and safe work practices, which are indispensable for contemporary production processes.

Thus, the system of vocational and practical training in the construction sector should be regarded as a key instrument for achieving sustainable development goals, rebuilding the economy, and integrating Ukraine into the European Higher Education Area. It must ensure the preparation of highly qualified personnel capable not only of effectively performing production tasks but also of participating in global projects, thereby contributing to sustainable development and the cultural progress of society.

4.5. ARTIFICIAL INTELLIGENCE TECHNOLOGIES IN ENSURING THE QUALITY OF PROFESSIONAL TRAINING FOR SPECIALISTS IN THE MOTOR TRANSPORT INDUSTRY

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The digital transformation of industry and transport infrastructure is reshaping the requirements for training specialists in the automotive sector. Ensuring the quality of vocational education in this field requires innovative tools that support adaptive learning, monitor skill acquisition, and improve training efficiency. Artificial intelligence technologies enhance quality assurance by enabling data-informed decision-making, personalized learning pathways, and continuous performance assessment. This study explores the potential of AI-driven solutions to improve the professional training of automotive transport specialists. Particular attention is given to intelligent learning systems, predictive analytics, automated assessment tools, and digital simulators that support the development of technical competencies and operational safety skills. AI-based monitoring allows educators to identify learning gaps, track progress in real time, and provide timely feedback, thereby increasing training effectiveness and reducing the risk of professional errors. The paper also highlights organizational and pedagogical conditions necessary for successful AI integration, including teacher digital competence, infrastructure readiness, and ethical considerations related to data protection and algorithmic transparency. The findings indicate that AI technologies contribute to improved training quality, better alignment with labor market demands, and strengthened safety-oriented professional behavior.

Keywords: *artificial intelligence (AI), vocational education, automotive transport training, quality assurance, adaptive learning, predictive analytics*

The digitalization of motor transport infrastructure and service processes drives a shift from fragmented quality control of workforce training to integrated solutions in which educational data, practical performance results, and production indicators are combined into a single monitoring framework. In this context, ensuring the quality of professional training for specialists in the motor transport sector becomes particularly important under martial law, when requirements for logistics reliability, transport safety, and the speed of restoring transport capacity increase, while the educational environment often operates in blended formats and under pressure from resource constraints.

The implementation of a data-informed management approach in the training of specialists for the motor transport sector involves the systematic use of learning analytics and algorithmic data processing to enable timely tracking of learners' progress,

identification of risks of lagging in competency development, and support for managerial decision-making based on evidential indicators (Ifenthaler & Yau, 2020, pp. 1964–1968, 1974–1976). The practical impact of this approach lies in the transition from formalized reporting to quality management as a continuous process, in which learning outcomes serve as the basis for refining program content, configuring practical training, and adjusting professional development trajectories.

Contemporary scholarly discourse in the field of educational technologies demonstrates a shift in emphasis toward the intellectualization of learning and the development of intelligent learning systems as tools for personalizing and adapting educational scenarios to individual learning dynamics (Roll & Wylie, 2016 , pp. 584–588, 592–594). This is particularly relevant for the motor transport sector, as the technological complexity of modern vehicles and service equipment increases the importance of practice-oriented learning models, simulators, and guided skills training, where errors in real-world environments carry a high risk threshold.

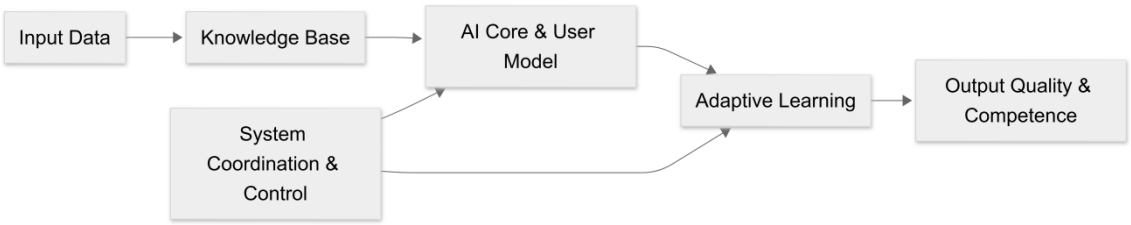
A significant analytical tool for supporting such decisions is learning analytics, understood as the systematic collection, processing, and interpretation of educational data aimed at improving learning effectiveness and enhancing pedagogical interventions. Studies focusing on the state and evidence base of learning analytics applications highlight the potential of analytical dashboards and predictive models for the early identification of problem areas in learning and for informed managerial decision-making at the institutional level (Viberg et al., 2018, pp. 100–104). In the context of training motor transport specialists, this approach can support quality control of diagnostic operations, the sequencing of technological procedures, and the stability of acquired safety-related skills, reinforced by timely and meaningful feedback as a key factor in learning progress (Hattie & Timperley, 2007, pp. 81–86, 90–93).

A distinct strand of contemporary research is associated with the use of artificial intelligence to transform mechanisms for ensuring educational quality, within which attention is focused on the shift from predominantly expert-driven and subjective assessment procedures to the systematic use of educational data and evidence-based foundations in managerial decision-making (Luckin et al., 2016, pp. 14–18). This approach involves the integration of analytical tools, adaptive educational technologies, and mechanisms for supporting pedagogical activity into a unified logic of operation of the digital learning environment.

Based on contemporary approaches to the application of artificial intelligence in education (Luckin et al., 2016, pp. 26–28), the interaction of analytical, adaptive, and managerial components of an AI-supported learning environment is synthesized and presented in Figure 4.1. The proposed model illustrates the interrelationships among sources of educational data, mechanisms for their algorithmic processing, and adaptive

learning tools, which together form a continuous loop for monitoring and improving the quality of professional training of motor transport specialists.

Figure 4.1. Conceptual model of AI-supported quality assurance in automotive vocational training



The presented model reflects the interrelationship between sources of educational data, artificial intelligence–driven analytical mechanisms, and adaptive learning tools that ensure continuous monitoring of the quality of specialist training. At the same time, systematic reviews emphasize that technological solutions must be pedagogically "embedded" in practice rather than exist as external, add-on instruments (Zawacki-Richter et al., 2019, pp. 8–11). For the motor transport sector, this means that AI tools should reinforce authentic pedagogical tasks, including the development of technological discipline, the cultivation of diagnostic culture, increased accuracy in the performance of operations, the standardization of assessment criteria, and support for learning in blended environments, including distance components. In the broader context, the design of digital learning spaces oriented toward adaptability and digital integration is viewed as a foundation for the development of new pedagogical models that align technology, content, and practical training (Gros et al., 2016, pp. 3–7, 21–24).

In this context, the current stage of development of educational technologies is characterized by the active penetration of artificial intelligence tools into various areas of professional training. Whereas in the early stages of digitalization learning management systems and electronic resources predominated, a transition is now taking place toward intelligent learning environments capable of analyzing educational data, adapting learning content, and supporting individualized professional development trajectories. These changes are driven by the need to increase learning effectiveness, ensure flexibility, and align education with the requirements of high-technology production.

Within scholarly discourse, artificial intelligence is viewed as a tool for supporting pedagogical and managerial decision-making based on the analysis of educational data and the prediction of learning outcomes. Machine learning algorithms make it possible to identify patterns in learners' educational activities, to detect difficulties in mastering content in a timely manner, and to generate personalized recommendations for further learning. In this context, learning analytics emerges as an effective means of enhancing

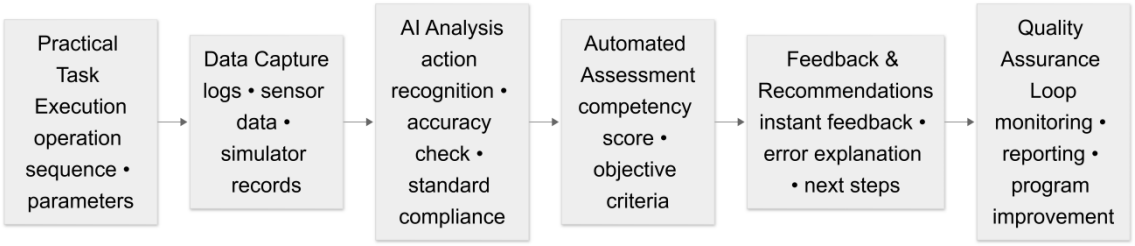
the effectiveness of the educational process and providing a rationale for pedagogical interventions.

One of the promising areas of artificial intelligence application is the development of adaptive learning systems capable of adjusting the complexity and sequence of learning materials in accordance with the learner's level of preparation. Such systems replicate the functions of individualized mentor support, provide immediate feedback, and contribute to the formation of sustainable professional skills. In vocational education, this is of particular importance, as it makes it possible to account for varying levels of learners' preparedness and differences in the pace of mastering technological operations.

Intelligent training systems and simulation environments play an important role by modeling production processes and providing opportunities to practice practical skills in safe conditions. The use of digital simulators enables the replication of complex production scenarios that are impossible or unsafe to model in real environments and fosters the development of algorithmic thinking, accuracy of actions, and professional responsibility. Research indicates that the application of simulation technologies enhances the acquisition of practical skills and reduces the adaptation period for specialists entering professional practice.

Artificial intelligence is also applied in the automated assessment of learning outcomes, ensuring objectivity and timeliness in evaluating competency development. Algorithmic systems can analyze the performance of practical tasks, record the sequence of operations, assess the accuracy of actions and compliance with technological standards, thereby contributing to the creation of a transparent evaluation system and increasing trust in the results of the educational process. A generalized structure of AI-supported automated assessment is presented in Figure 4.2.

Figure 4.2. AI-based automated assessment of learning outcomes



The structure presented in Figure 4.2 illustrates the sequence of data collection on the performance of practical operations, their algorithmic analysis, and the generation of objective assessment indicators. Recording task performance parameters, logging the sequence of technological actions, and verifying their compliance with established standards enable a comprehensive evaluation of professional competencies in real time.

The algorithmic processing of such data ensures not only the accuracy and impartiality of assessment but also the timely provision of feedback, which facilitates the correction of errors and the improvement of practical skills. As a result, a transparent system for monitoring the quality of learning is established, trust in the outcomes of the educational process is increased, and the foundation is laid for the continuous refinement of professional training programs in accordance with industry technological standards.

At the same time, the effectiveness of artificial intelligence technologies in vocational education is determined not only by the technical capabilities of the systems but, above all, by the pedagogical appropriateness of their integration. AI does not replace the instructor; rather, it expands their professional capabilities by providing tools for analyzing learning progress, individualizing instruction, and supporting learners in the development of professional competencies. It is precisely the combination of technological innovation and pedagogical expertise that creates the conditions for improving the quality of professional training in the context of the digital transformation of education.

The professional training of specialists in the motor transport sector is characterized by a high level of technological complexity and the multi-component nature of production processes. Modern vehicles are integrated technical systems that combine mechanical, electronic, computerized, and sensor subsystems, as well as digital control and monitoring systems (Bosch, 2022). This necessitates the development in future specialists of systemic technical thinking, the ability to work with digital diagnostic complexes, and an understanding of the principles of electronic control system operation.

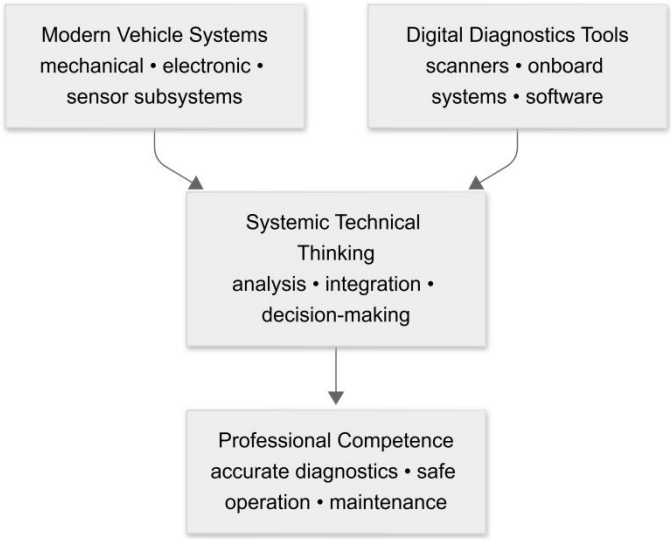
The increasing technological complexity of modern vehicles and the widespread use of digital diagnostic systems are changing the requirements for professional training of specialists in the motor transport sector. Effective performance of diagnostic, service, and operational tasks requires not only knowledge of individual technical components but also the ability to integrate information from mechanical, electronic, and sensor subsystems into a unified system of technical analysis. Under such conditions, the development of systemic technical thinking becomes particularly important, enabling analytical understanding of technical processes, the making of informed decisions, and adherence to safe professional practice procedures.

The use of digital diagnostic tools – such as electronic scanners, onboard computer systems, and specialized software – facilitates a shift from intuitive fault detection to evidence-based diagnostics grounded in data analysis. This, in turn, improves the

accuracy of technical decisions, the efficiency of maintenance, and the safety of vehicle operation.

The generalized interrelationship between the technological complexity of transport systems, the use of digital diagnostic tools, and the development of professional competence in motor transport specialists is presented in Figure 4.3.

Figure 4.3. Development of systemic technical thinking and professional competence in automotive specialists in the context of digital diagnostics.



A significant aspect of professional training is the safety component, as work in the motor transport sector is directly associated with risks to human life and health. Developing safety-oriented professional behavior involves mastering vehicle operation standards, maintenance procedures, action algorithms in critical situations, and compliance with occupational health and safety requirements. In this context, the accuracy of performing technological operations and accountability for outcomes becomes crucial, as errors in technical maintenance can lead to serious operational risks (International Labour Organization, 2020).

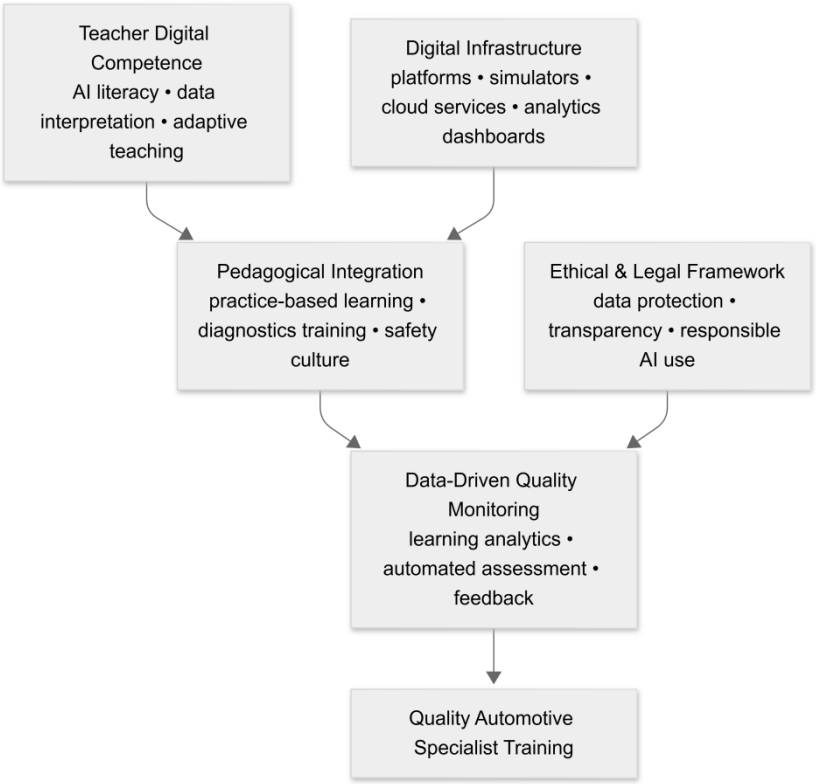
Equally important is diagnostic activity, which involves the use of electronic scanners, onboard computer systems, sensor modules, and specialized software for fault detection. Modern technical diagnostic technologies require specialists to be able to interpret digital data, analyze the operating parameters of components, and make informed decisions regarding maintenance and repair, in line with the development trends of intelligent transportation systems and digital diagnostics (Sussman, 2014).

The service component of professional activity is also undergoing significant transformation under the influence of the digitalization of transport infrastructure. High standards of service, the integration of information systems for managing service processes, and the use of electronic technical information databases require specialists to possess communication competence, client-oriented skills, and the ability to operate effectively in a digital service environment.

Thus, the nature of professional activity in the motor transport sector necessitates the integration of technical training, safety culture, diagnostic competence, and service orientation. This multidimensionality of professional requirements underscores the need to implement innovative educational approaches capable of ensuring high-quality training of specialists in accordance with contemporary technological and production standards.

To present the organizational and pedagogical conditions for implementing artificial intelligence technologies in a clear and concise manner, it is advisable to summarize them in the form of a structural model that illustrates the interaction of pedagogical, technological, and managerial components of the learning environment (Figure 4.4).

Figure 4.4. Organizational and pedagogical conditions for implementing AI technologies in quality assurance of automotive vocational training.



The presented model illustrates the interrelationship between instructors' professional readiness, digital infrastructure, and the pedagogical integration of intelligent technologies into the learning process. The use of learning analytics and automated assessment ensures continuous monitoring of learning outcomes, while ethical and legal principles guarantee the responsible use of data. The alignment of these conditions provides a foundation for improving the quality of specialist training and enables the adaptation of the educational process to the requirements of a digitalized motor transport sector.

Despite the significant potential of artificial intelligence technologies in ensuring the quality of professional training for specialists in the motor transport sector, their implementation is accompanied by a range of challenges and limitations of a technological, pedagogical, organizational, and ethical nature.

The integration of intelligent systems into vocational education occurs amid uneven digital readiness of educational institutions, limited funding, and the need to update material and technical resources. At the same time, the use of algorithmic solutions in assessment and monitoring of learning outcomes requires ensuring transparency, protecting personal data, and preventing algorithmic bias.

A significant challenge remains the level of digital readiness among teaching staff. Insufficient experience in using educational data analytics and AI tools may limit their pedagogical potential and lead to the formal application of technologies without integration into didactic practice. Moreover, there is a risk of excessive technologization of learning, where digital solutions replace pedagogical interaction, potentially reducing learner motivation and weakening the development of professional responsibility.

An important aspect is the technical limitations related to data quality, software system compatibility, and the stability of digital infrastructure. Incomplete or incorrect data can affect the accuracy of analytical conclusions, necessitating the combination of algorithmic solutions with expert pedagogical evaluation. In the context of professional training for the motor transport sector, this is particularly significant, as errors in assessing the development of practical skills may have safety implications.

Despite the significant potential of artificial intelligence technologies in ensuring the quality of professional training for specialists in the motor transport sector, their implementation is accompanied by a range of technological, pedagogical, organizational, and ethical challenges and limitations. The integration of intelligent systems into vocational education occurs amid uneven digital readiness of educational institutions, limited funding, and the need to update material and technical resources. At the same

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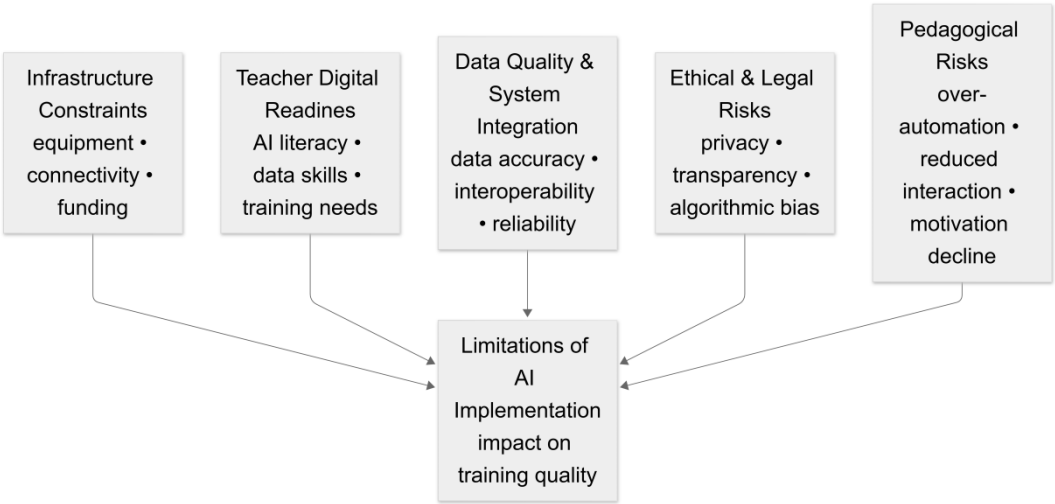
Moreover, there is a risk of excessive technologization of learning, where digital solutions replace pedagogical interaction, which can reduce learner motivation and weaken the development of professional responsibility.

Attention should also be given to technical limitations related to data quality, software system compatibility, and the stability of digital infrastructure. Incomplete or inaccurate data can affect the accuracy of analytical conclusions, necessitating the combination of algorithmic solutions with expert pedagogical evaluation. In the context of professional training for the motor transport sector, this is particularly important, as errors in assessing the development of practical skills may have safety implications (Figure 4.5).

Figure 4.5. Challenges and limitations of implementing AI technologies in automotive vocational training



The presented diagram summarizes the main factors that may limit the effective use of artificial intelligence technologies in vocational education. Infrastructure constraints, the digital readiness of instructors, data quality, and system compatibility affect the efficiency of analytical processes and adaptive learning. At the same time, ethical risks and pedagogical challenges require a responsible and balanced approach to

the implementation of AI tools. Considering these factors helps minimize risks and ensures the appropriate use of intelligent technologies to enhance the quality of professional training.

The synthesis of research findings indicates that the digital transformation of the motor transport sector is significantly changing the requirements for the quality of professional training of specialists. The technological complexity of modern vehicles, the widespread use of digital diagnostics, and heightened demands for safety and service interaction create a need for the development of systemic technical thinking, diagnostic culture, and responsible professional behavior.

The application of artificial intelligence technologies creates new opportunities for ensuring the quality of training. Intelligent trainers and simulators support the development of practical skills in a safe environment, learning analytics enables the timely identification of learning difficulties, automated assessment enhances the objectivity of competency evaluation, and adaptive systems support individualized professional development trajectories for learners.

The effectiveness of using AI technologies depends on the organizational and pedagogical conditions of their implementation, primarily: the digital readiness of instructors, the availability of modern infrastructure, the pedagogically balanced integration of intelligent tools into the curriculum, and adherence to ethical principles in handling data. At the same time, the implementation of artificial intelligence is accompanied by challenges related to uneven digital capacity of educational institutions, the need to enhance instructors' qualifications, and the assurance of the reliability of educational data.

Thus, the use of artificial intelligence technologies facilitates a shift toward evidence-based management of professional training quality, the enhancement of safety culture, and the alignment of acquired competencies with the current requirements of the motor transport sector. Future research prospects are associated with the development of adaptive learning environments and the improvement of methods for integrating AI solutions into the practical training of specialists.

4.6. ENERGY SAVING PROJECT MANAGEMENT IN CONSTRUCTION AS A MEANS OF IMPROVING THE QUALITY OF PROFESSIONAL TRAINING OF SPECIALISTS

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Legislative acts and regulatory documents governing the formation of professional energy efficiency competence of construction industry specialists for the green recovery of Ukraine have been analysed. It is part of the European Competence Framework (GreenComp). In accordance with this competence framework, the implementation of energy conservation projects will contribute to the creation of conditions for the formation of environmental and energy efficiency competence among construction industry specialists, which will contribute to improving the efficiency of energy use in Ukraine, the rational use of state and local budget funds, and will contribute to increasing the energy independence and energy security of the state. Successful project management of energy conservation in construction as a means of improving the quality of professional training of specialists requires graduates of higher and professional education institutions to have integrated approach skills, where technical, economic, social and environmental aspects are considered as integral parts of a single plan for these projects. Participation in energy conservation projects in construction through the implementation of a flexible, qualified modular approach to the design of curricula and educational programmes contributes to the formation of professional competence in energy efficiency and energy conservation. Energy efficiency projects enable students to acquire practical skills and abilities to apply modern technologies and materials and are an effective means of improving the quality of professional training for specialists in the construction industry.

Keywords: *energy efficiency competence, energy management, energy efficiency standards, green transition*

The Association Agreement with the European Union defines Ukraine's goals and objectives in various areas. In particular, Chapter 23, “Education, Training and Youth”, Article 432 states that in the field of vocational education, Ukraine and the EU aim to develop vocational education and lifelong learning systems that respond to changes in the labour market, as well as creating national mechanisms that would make it possible to improve the recognition of qualifications and competences, using, where possible, the experience of the EU (Verkhovna Rada of Ukraine, 2014).

Green transition training helps learners of all ages to acquire the knowledge, skills and attitudes necessary for a more sustainable future, which manifests itself in changing

consumption and production patterns, adopting healthier lifestyles and contributing, both individually and collectively, to a more sustainable economy and society. It also promotes the development of skills and competences that are increasingly in demand in the labour market and helps to understand the interrelated global challenges that lie ahead – environmental degradation and biodiversity loss. All global challenges have environmental, social, economic and cultural dimensions (Council of the European Union, 2022b).

The green transition also involves energy savings, which leads to a reduction in harmful emissions and lower costs for the implementation of new energy capacities. Thus, the European Commission's report "Clean Energy for All Europeans" of 30 November 2016 proposed a fourth energy package, which envisages increasing the share of electricity production from renewable energy sources to 50% of total production by 2030 (European Commission, 2016). It was proposed with the aim of prioritising energy efficiency, achieving EU global leadership in renewable energy sources and ensuring fair conditions for consumers.

In accordance with the requirements of this energy package, Ukraine has introduced a new Energy Strategy until 2050 (Ministry of Energy of Ukraine, 2023). The document takes into account: the consequences of the Russian Federation's full-scale war against Ukraine (strengthening the role of energy security and the resilience of the energy system); the results of connecting Ukraine's energy system to the European network of operators; the introduction of the latest technologies, global trends and innovative solutions that meet the requirements of environmental safety in accordance with EU standards and Ukraine's international commitments on energy efficiency; the decentralisation of electricity generation throughout the country to improve the stability and reliability of energy supply.

The European Commission's energy package states that buildings account for 40% of total energy consumption. Therefore, developing the energy efficiency expertise of construction industry professionals for Ukraine's green recovery is becoming a strategic priority. This means training construction industry specialists who are competent in the thermal modernisation of buildings and bringing construction standards into line with energy efficiency standards.

Therefore, developing the energy-saving competence of graduates in higher and vocational education institutions in the construction industry is one of the main factors influencing the energy efficiency of the Ukrainian economy. This competence is part of the European Sustainable Development Competence Framework.

In 2022, the European Commission defined the European Competence Framework for Sustainable Development (GreenComp), which includes competencies organised into four areas (Bianchi et al., 2022, p. 2), see Table 4.1.

We will begin the formation of energy-saving competencies among graduates of the institution of pre-higher professional education in the construction industry with an analysis of the educational and professional programme (EPP): "Finishing of buildings and structures and construction design" (Chernivtsi Professional College of Lviv National University of Natural Resources, 2023) of the separate structural unit "Chernivtsi Vocational College of Lviv National University of Natural Resources" compiled in accordance with the "Standard of Vocational Pre-Higher Education (hereinafter referred to as the Standard): educational and professional degree – junior bachelor, field of knowledge 19 "Architecture and Construction", specialty 192 "Construction and Civil Engineering" (Ministry of Education and Science of Ukraine, 2021) and the educational program of vocational education in the profession "Tiler" (Educational content portal for vocational education, 2024) of the municipal vocational education institution "Novovolynsk Centre for Vocational Education" of the Volyn Regional Council, compiled on the basis of the "State Educational Standard" for the profession 7132 "Tiler", approved by Order of the Ministry of Education and Science of Ukraine No. 289 of 8 March 2024 (Ministry of Education and Science of Ukraine, 2024a).

Thus, in the institution of pre-higher professional education, the OPP developed by the working group adds to the competencies included in the Standard the general competency (GC 10) "Implementation of safe activities with protection of the environment. Understanding the need for and adherence to a healthy lifestyle" and special competencies (SC 13) "Ability to apply basic legislative provisions on occupational safety and environmental protection; apply basic methods of life safety and civil protection of production personnel and the population from the possible consequences of accidents, disasters, natural disasters, possession of a culture of safety, environmental awareness" (SK 14) "Knowledge and practical application of resource-saving and energy-saving technologies, alternative and renewable energy sources, understanding of the environmental consequences of one's professional activities". Unfortunately, the programmes of other institutions of higher vocational education in the speciality 192 "Construction and Civil Engineering" hardly take into account the "Energy Strategy of Ukraine for the period up to 2050".

Taking the example of the educational programme for the profession of "Tiler" at the Novovolynsk Centre for Vocational Education, a municipal vocational education institution of the Volyn Regional Council, we see that the Standard includes the key competence (KC6) "Environmental and energy efficiency competence". This

competency is also included in the standards for other professions (bricklayers, carpenters, joiners, etc.) and requires graduates to know: the basics of energy efficiency; regulatory and legal acts in the field of energy conservation; ways to use materials, resources and energy-saving equipment in a energy-efficient manner in professional activities and everyday life; regulatory and legal acts in the field of ecology; the basics of rational use, reproduction and conservation of natural resources; ways to preserve and protect the environment in professional activities and everyday life; modern eco-friendly building materials and ways to recycle and process construction waste, as well as be able to: use energy resources and consumables wisely in their professional and personal lives; use energy-efficient equipment and follow environmental standards in their professional and personal lives.

The Ministry of Education and Science of Ukraine is integrating the topic of energy efficiency into the school curriculum. This project is part of a broader initiative to introduce the topic of green energy into education as part of the LEARN project (Ministry of Education and Science of Ukraine, 2024b). There are plans to develop teaching modules and integrate them into the curriculum. The integration of the topic will not create an additional workload, but will offer materials for relevant topics in the curriculum to make them more relevant. Such integration is also recommended for the model curricula “Exploring Nature”, STEM, “Environment”, “Technology”, “Natural Sciences”, “Entrepreneurship and Financial Literacy”, and “Economics” (Shelimanova et al., 2025).

That is, applicants to higher education institutions with basic secondary education (while completing a two-year specialised secondary education programme) will additionally study energy efficiency and alternative energy sources in buildings. In addition, compulsory educational components that form general competencies (OK 7) through the study of the academic discipline “Ecology and Environmental Protection”.

Those seeking to become “Tilers” with basic secondary education receive a complete general secondary education in vocational education institutions and, accordingly, study educational modules on energy conservation, which are integrated into the curriculum for grades 10–11. In addition, the subject “Fundamentals of Energy Efficiency and Ecology” is studied as part of general vocational training, and interested graduates can develop additional competence by studying the subject “Advanced Systems for Thermal Modernisation of Buildings and Structures”.

Teaching young people about energy efficiency and energy conservation in pre-higher and vocational education institutions in the construction industry requires an interdisciplinary approach and interdisciplinary coordination. Currently, there is an

urgent need to make disciplines related to the interaction between society and the natural environment more environmentally friendly. This focus (educational modules on energy efficiency) needs to be strengthened in the study of educational disciplines, not only in compulsory educational components that form general competencies, but also in compulsory educational components that form special competencies, selective educational components and practical training in pre-higher vocational education institutions, as well as subjects of general professional training and professional-theoretical training and professional-practical training in vocational education institutions.

Thus, the environmental and energy efficiency competence of future builders is the key to creating energy-efficient, environmentally safe and modern buildings. Its formation should become an integral part of the educational process in vocational education institutions in the construction industry (Gerliand et al., 2025, p. 14).

According to the National Standard of Ukraine in the field of energy management DSTU ISO 50001:2020 (ISO 50001:2018, IDT), energy efficiency is a ratio (coefficient) or other quantitative relationship between the obtained performance indicator, i.e. between the work performed, services rendered, goods produced or energy generated, and the input indicator, i.e. the level of energy consumption (Ukrainian Scientific Research and Training Center for Standardization Certification and Quality, 2020).

Project management of energy conservation in construction is one of the effective means of improving the quality of professional training of specialists. This is the case with the project "Promoting Energy Efficiency and Implementing the EU Energy Efficiency Directive in Ukraine", which was implemented in Ukraine by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of the German and Swiss governments. This project was implemented with financial support from Germany (€7.3 million) and Switzerland (€5.15 million), lasted five years (July 2020 – June 2025) and had the following components (GIZ, 2025):

- Energy efficiency reform component in Ukraine;
- Energy efficiency component in communities;
- Vocational training component;
- Energy efficiency consulting for businesses.

As we can see, the third component deals with qualifications and vocational training in the energy efficiency sector and bridges the gap between the needs of the private sector and labour market demand.

This means that specialists and students have broad access to qualifications in the field of energy efficiency, namely:

- the development of competencies provided for in the Green Deal;
- raising awareness of energy efficiency among various groups of young people, with a focus on students of vocational education institutions (VEIs), and especially on women and girls.
- creating an innovative space for learning, research and dynamic solutions in the field of energy efficiency, and building the capacity of educational institutions.

Energy Innovation Hubs have been established at three Ukrainian universities, equipped for practical training in energy efficiency and integrated into the university structures. These centres serve as places where schoolchildren, vocational school students and university students learn about energy efficiency, familiarise themselves with and test modern equipment and materials.

A course on "Supervision of Construction Works" has been developed, accredited by the Dnipro State Academy of Civil Engineering and Architecture, and included in the master's programme of the O.M. Beketov National University of Urban Economy in Kharkiv.

Training of junior bachelors competent in the basics of energy conservation management in construction is carried out under the educational programme "Engineering Systems and Energy Conservation of Buildings and Structures" of the Kyiv Professional College of Architecture, Construction and Management in the speciality G 19 "Construction and Civil Engineering". Thus, graduates acquire special competence SK 10 – "Understanding of technological processes during the construction, finishing, operation, repair and reconstruction of construction objects and engineering networks in compliance with occupational health and safety and environmental protection requirements", and in the learning outcomes RN 23, graduates must "Be able to effectively solve tasks and complex problems in the field of heat and gas supply, climate systems and energy conservation by applying knowledge on the use of renewable and non-traditional energy sources, the organisation of rational energy accounting and automated control of heating, ventilation and air conditioning systems to ensure optimal climatic conditions in premises".

The formation of special competence SC 10 is carried out through the study of academic disciplines that form both general and special competences: "Environmental monitoring and methods of biosphere protection", "Heating of buildings and their energy efficiency" and "Energy conservation of buildings and structures". In addition, at the discretion of the applicant for higher professional education, the academic disciplines "Use of Renewable Energy Sources" and "Management and Marketing" can be studied from the selective educational components of the OOP. A junior bachelor's degree in

construction and civil engineering provides the opportunity to continue studying for a higher education degree and take the course “Supervision of Construction Works” (Kyiv Professional College of Architecture Construction and Management, 2025).

Promotion of vocational education professions among women and girls through events such as Energy Days and Job Fairs.

Based on the results of a comprehensive study entitled “Involvement of women, girls and vulnerable groups in the energy-efficient restoration of Ukraine”, conducted in January–February 2025, the results of two surveys (3,995 and 211 women and girls, respectively) and a series of focus group studies (50 people) were summarised to identify the key factors influencing women's willingness to choose construction or technical specialities in the field of energy efficiency, the main barriers to their involvement, and the motivational factors influencing their choice. Recommendations were made to the Ministry of Education and Science of Ukraine, higher and vocational education institutions, local state (military) administrations, local self-government bodies, businesses and non-governmental organisations on improving the involvement of women and girls in training, upgrading their skills and expanding their participation in the field of energy-efficient reconstruction of Ukraine (Hubeladze et al., 2025).

Seventeen partner vocational education schools have been selected to receive technical support for the pilot implementation of four short-term training programmes, training for teachers, and cooperation with potential employers.

It is particularly important to focus on the aspect of training for teachers. They not only create an innovative space for learning, research and dynamic solutions in the field of energy efficiency, but also undergo practical training in energy conservation project management in construction. Thus, based on the results of the research conducted by our department, we identified the main pedagogical conditions that can effectively influence the development of energy efficiency competence in future construction industry specialists, namely: “The availability of teachers who possess energy efficiency competence and the improvement of their qualifications in the field of energy efficiency technologies”; “The use of active teaching methods (project-based learning, case studies, etc.) to develop energy efficiency competence”; “The creation of an appropriate creative educational environment that will influence the development of energy efficiency competence in students” (Kalenkyi, 2025).

In autumn 2022, vocational education institutions were given a unique opportunity to participate in a new project: “Energy-efficient educational institution. Thermal modernisation of vocational education institutions within the framework of developed energy efficiency courses”, which is being implemented by the Charity Fund Human in

cooperation with the Ministry of Education and Science of Ukraine and GIZ. Among the five winners of the competitive selection was the Zaporizhzhia Higher Vocational School. As part of the project, educational programmes were developed and approved at the college for short-term programmes to provide partial professional qualifications in "Window and Door Installation" and "Advanced Thermal Modernisation Systems for Buildings and Structures" (Department of Education and Science of the Zaporizhzhia Regional State Administration, 2023).

Thanks to the project "Just Transition of Coal Regions and Green Recovery of the Energy Sector in Ukraine" implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of the German Federal Ministry for Economic Affairs and Energy, a Renewable Energy Centre has been established at the Chervonohrad Professional Mining and Construction Lyceum. The centre has launched the first solar panel installer training programme in the Lviv region. In the context of the energy crisis caused by the war, such initiatives contribute to energy security, integration into the European space and the just transition of coal regions. For the pilot Lviv region and the Chervonohrad micro-region, action plans are being developed and implemented, the main points of which are energy transformation and sustainable economic development, which involves professional retraining measures taking into account the needs of the local labour market, as well as "green" educational programmes for vocational education institutions. For example, about 300 people have completed vocational training and advanced training courses, of which about 50 have been trained in renewable energy at a vocational school. In addition, a concept for the creation of an industrial park has been developed, which is expected to create more than 3,000 jobs (GIZ, 2024).

Thus, participation in energy efficiency projects in construction through the implementation of a flexible, qualified, modular approach to the design of curricula and educational programmes contributes to the development of professional competence in energy efficiency and energy conservation. Energy efficiency projects enable students to acquire practical skills and abilities to apply modern technologies and materials and are an effective means of improving the quality of professional training for specialists. This requires graduates of higher and vocational education institutions to have skills in an integrated approach, where technical, economic, social and environmental aspects are considered as integral parts of a single plan for these projects.

4.7. INTRODUCTION OF ARTIFICIAL INTELLIGENCE INTO THE EDUCATIONAL AND PRODUCTION ENVIRONMENT OF A VOCATIONAL EDUCATION INSTITUTION IN THE MOTOR TRANSPORT INDUSTRY

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The section conceptualizes the transformation of vocational education and training (VET) for the automotive industry through the implementation of AI-driven adaptive learning systems. It shifts the focus from standardized instruction to personalized digital trajectories, integrating global engineering trends with local educational needs. The research reveals the potential of interactive simulations and AI platforms in ensuring adequate specialist training for operating high-tech equipment and complex production systems. Drawing on the latest 2025 empirical data, the research evaluates the prospects of AI in Ukraine's dual education system, identifying its role in bridging the skills gap and mitigating digital inequality. It highlights the critical necessity of synergy between automated assessment tools and human mentorship. The findings provide a strategic framework for the digital evolution of VET, combining advanced infrastructure with the development of teachers' digital competencies to ensure the training of competitive, future-ready automotive professionals.

Keywords: *artificial intelligence, adaptive learning, vocational training, dual education, automotive industry, skills gap, digital readiness*

The current stage of global economic development is characterized by a rapid transition to the fourth industrial revolution (Industry 4.0), where artificial intelligence (AI) is the basic determinant of technological progress. For the automotive industry, this transition is the most radical, as it involves the simultaneous electrification, digitization, and automation of vehicles. The emergence of advanced driver assistance systems (ADAS), the development of unmanned technologies, and the introduction of cloud services for managing big data in logistics are fundamentally changing the requirements for skilled workers.

The relevance of introducing artificial intelligence into the educational and production environment of vocational education institutions (VEIs) specializing in motor transport is determined by a number of key factors that determine the viability of the industry in the context of digital transformation. First, the key challenge is the growing technological gap. The current pace of updating the model range of vehicles and the rapid complication of their software significantly outpace the traditional cycles of updating

curricula and methodological support. In this context, artificial intelligence technologies are an effective tool for overcoming this gap through the integration of “digital twins” into the educational process. This creates conditions for students to master the most advanced intellectual diagnostic systems in a virtual environment, which eliminates the acute need for constant high-cost purchases of physical equipment, which in the conditions of Industry 4.0 becomes obsolete faster than the training cycle of a specialist is completed.

Secondly, there has been a fundamental shift in the maintenance paradigm. The traditional approach, based on reactive repairs “after a breakdown,” is being transformed into predictive (forecasting) service. Accordingly, a modern skilled worker in the automotive industry must have the skills to work with machine learning algorithms that are capable of analyzing large amounts of data (Big Data) from vehicle sensors in real time. This requires the educational environment of vocational schools to develop new competencies related to interpreting the results of neural networks that predict the condition of vehicle components and assemblies.

Thirdly, the introduction of intelligent systems directly correlates with Ukraine's strategic reconstruction needs. In the post-war period, an effective logistics system and modernized road transport infrastructure will become a critically important foundation for national economic recovery. The viability and reliability of this network will depend on specialists capable of working productively in a “smart” production environment, using AI to optimize routes, minimize equipment downtime, and improve road safety. As Radkevych (2023, pp. 5–6) notes, the professional and practical training of future specialists is one of the key prerequisites for the successful implementation of modern vocational education tasks. Such training should be aimed at ensuring rapid scientific and technological progress and overcoming the global challenges facing the national labor market in the context of the country's recovery.

In addition, the introduction of AI in vocational education solves the problem of personalizing learning. The automotive industry requires highly specialized knowledge (e.g., servicing hydrogen fuel cells or calibrating lidars), which is difficult to teach on a mass scale. Intelligent learning systems allow content to be adapted to the pace and needs of each student. In this context, vocational training ceases to be linear, becoming a multidimensional process of interaction between humans and algorithms.

The systematic introduction of artificial intelligence (AI) into the educational and production environment of vocational education institutions (VEIs) in the automotive industry is based on a multi-level system of regulatory and legal acts. This architecture ensures the legitimacy of the use of innovative technologies, defines the requirements for

the digital competencies of participants in the educational process, and establishes ethical limits for the application of algorithms.

The fundamental basis is the Law of Ukraine "On Education" (Verkhovna Rada of Ukraine, 2017a). In particular, Article 12 defines information and communication competence as one of the key competences necessary for every modern person to live a successful life. Article 54 imposes on teachers the obligation to continuously improve their professional level and digital literacy, which is critical for the integration of AI into the teaching of technical disciplines. In addition, Article 42-1 regulates issues of academic integrity, which is particularly important when using generative AI in the educational process.

Specialized regulation of the industry is carried out in accordance with the Law of Ukraine "On Vocational Education" (Verkhovna Rada of Ukraine, 2025c). This act became the basis for a radical transformation of the specialist training environment. Article 4 of the Law legitimizes the creation of digital educational spaces and virtual laboratories, allowing vocational education institutions to integrate "digital twins" of cars into the educational process. Article 21 emphasizes that the content of training should be based on professional standards developed with the latest technological forecasts in mind, including autonomous driving and neural network diagnostics.

The strategic vector for the implementation of intelligent systems in Ukraine is defined by the Concept for the Development of Artificial Intelligence in Ukraine (Verkhovna Rada of Ukraine, 2020a). The document defines education as a priority area for the use of adaptive learning systems.

The international dimension of regulatory control is represented by European Union documents, which are mandatory in the context of Ukraine's European integration. The key document is the Digital Education Action Plan (2021–2027), which focuses on building highly productive digital ecosystems (European Commission, 2021). The European Digital Competence Framework for Educators (DigCompEdu) is used to assess staff readiness. It details the requirements for teachers to use data and AI tools to personalize learning (Redecker, 2017).

The European AI Act (Council of the European Union, 2024) occupies a special place as the world's first comprehensive AI law. It classifies AI systems used in education and vocational training as "high-risk systems". This requires educational institutions to comply with strict standards of algorithm transparency, data quality, and cybersecurity when implementing intelligent diagnostic and assessment systems for students.

Therefore, creating a flexible and modern regulatory framework is critical to ensuring the predictive nature of vocational education, allowing VET institutions to

respond quickly to global technological challenges and the country's reconstruction needs. Such synergy between national and international legislation creates a solid foundation for the digitalization of the automotive industry in Ukraine.

Research into the integration of artificial intelligence (AI) into the educational process of vocational education institutions requires deductive analysis: from global automation strategies to applied methods of training specialists.

Contemporary foreign scientific thought considers the transformation of the transport sector through the prism of the Industry 4.0 and Industry 5.0 concepts. In particular, studies justify the transition to predictive maintenance, where the key skill of a specialist is the ability to interact with AI algorithms that analyze big data from car sensors (Donthula & Uparkar, 2025). This radically changes the training profile: from "mechanic-performer" to "technical systems analyst".

An analysis of global trends presented in a systematic review by Liu, Wang, & Wang (2025) indicates that artificial intelligence is becoming a key tool for transforming engineering education. The researchers emphasize that the integration of intelligent systems allows a shift from traditional teaching methods to personalized models that can adapt to each student's pace of learning. The systematic approach to AI implementation described by the authors confirms the need to create comprehensive digital ecosystems that combine a theoretical foundation with interactive tools for modeling production processes.

Domestic scientific discourse adapts these global challenges, relying on strategic developments in the predictive development of vocational education in a dynamic labor market (Radkevich, 2023, pp. 5–6). These studies create a methodological platform for the development of a proactive educational environment focused on the technological needs of Ukraine's reconstruction.

A more specialized level of analysis is presented in works related to the design of computer-oriented environments for training specialists in equipment operation. In this context, the role of artificial intelligence (AI) as a strategic resource for the development of vocational education has been substantiated. This includes the identification of key directions for AI integration into the national educational system in accordance with European standards (Hurzhii & Pryhodii, 2025).

The applied aspects of training skilled workers are based on didactic models that focus on practice-oriented learning. In particular, Homeniuk (2014) investigated the methodology for developing the professional competence of vehicle repair mechanics, and Dynko (2015) justified the use of technical teaching aids for visualizing repair

processes. Kononenko (2018) identified the features of IT application in the general technical training of future skilled workers.

An important element is the formation of professional mobility, which allows specialists to adapt to constant technological updates (Dubinina, 2016). The results of a study on the readiness of future workers in the automotive industry to apply innovative production technologies (Romanov, 2021) deserve attention. The author identifies four components of such readiness: motivational-value, subjective, cognitive, and activity-related.

The most up-to-date overview of the problem (2024–2025) is presented in the works of Voloshyn, which analyze the state of training for mechanics in the context of total digital transformation (2024). The researcher emphasizes the need to update the content of training in line with the emergence of new intelligent diagnostic systems, which requires the formation of specific digital competencies in future mechanics.

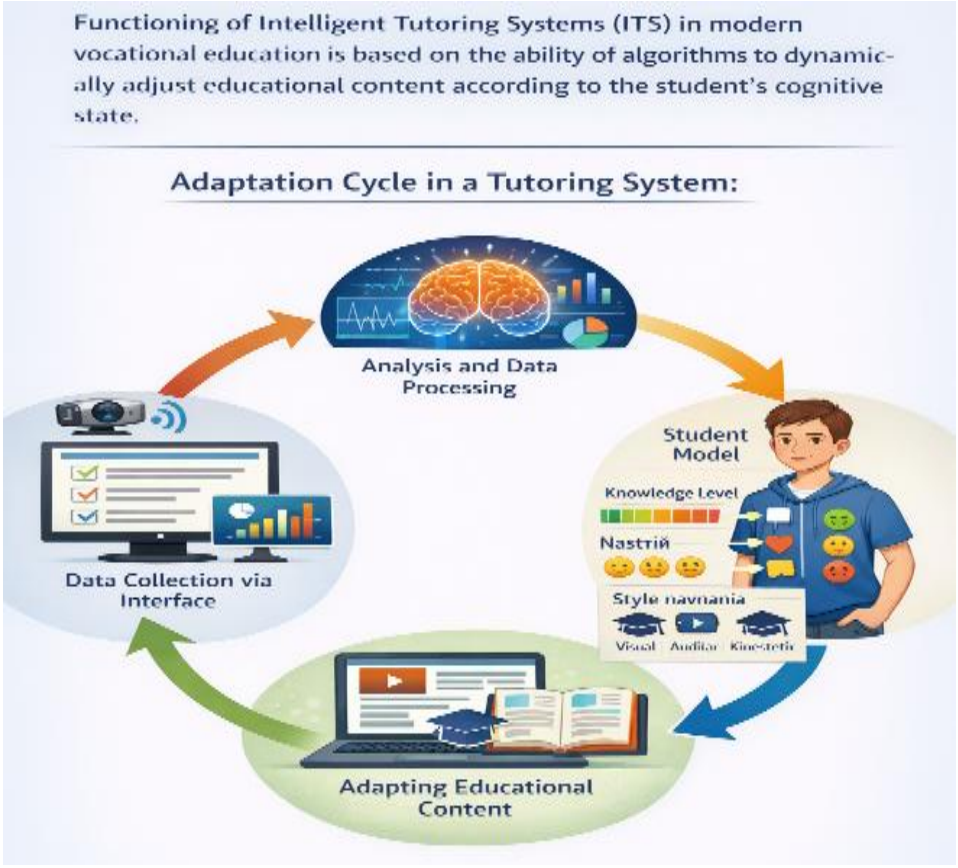
Traditional models of organizing the educational process, focused on the average level of training of a group, are increasingly less relevant to the realities of modern professional education, where there is significant differentiation among applicants in terms of their level of basic knowledge, pace of learning, and professional motivation. The use of simulators, digital trainers, and learning data analytics systems creates the conditions for a transition to more flexible models of educational process management.

It is at this stage that theoretical provisions regarding blended learning, algorithmization of the educational environment, and professional interpretation of digital data acquire an applied dimension. There is a need to consider technological solutions that ensure the adaptation of educational content to the individual characteristics of the learner, automated diagnosis of the level of competence development, and correction of the educational trajectory in real time.

Such a tool is adaptive learning systems based on artificial intelligence, which integrate mechanisms for analyzing large data sets, modeling cognitive processes, and predicting learning outcomes. Their use in vocational education institutions opens up new opportunities for improving the effectiveness of training, while at the same time raising questions about pedagogical expediency, the validity of assessment, and the preservation of the practical orientation of training.

The functioning of intelligent tutoring systems (ITS) in the modern educational space of vocational education is based on the ability of algorithms to dynamically adjust learning content according to the cognitive state of the student. The main mechanism of such a system is the “adaptation cycle,” which begins with the collection of primary data through the interface and its subsequent processing in the student model (Figure 4.6).

Figure. 4.6. ITS adaptation cycle



According to Brusilovsky (2021), modern adaptive systems have moved from simple scenario branching to complex intelligent trajectory analysis, where each student's step is compared to a reference knowledge model. In the context of training specialists in the automotive industry, this allows the system not only to record an error during virtual engine diagnostics, but also to analyze the cause of its occurrence – whether it is a lack of theoretical knowledge or a violation of the logical sequence of actions.

The mathematical basis for such systems is often Bayesian knowledge networks or hidden Markov process models, which allow the tutoring model to make decisions under conditions of uncertainty. According to Woolf's (2022, pp. 123–126) methodology, an effective ITS should provide so-called "scaffolding," where the level of assistance provided by the system automatically decreases as the student's competence increases. This is critically important for VET, as it allows for a gradual transition from guided learning to independent performance of complex technological operations. The predictive capabilities of AI in such systems, as noted by Luckin, Holmes, Griffiths and Forcier (2016), transform the role of the teacher, freeing them from routine control and allowing

them to focus on complex case studies where human intuition and experience still surpass algorithms.

Special attention in ITS architecture is paid to the semantic structuring of the subject area. For the automotive profile, this means creating ontologies of technical systems of a vehicle, where each node is associated with a corresponding set of diagnostic tasks. The implementation of intelligent agents within such a system allows for the autonomous generation of new learning tasks, dynamically tailored to the identified skill gaps of an individual student. By continuously calibrating the difficulty level, the system maintains an optimal cognitive load, thereby ensuring the continuity of the educational process and preventing the loss of motivation – whether from excessive complexity or lack of challenge. Thus, the introduction of ITS in the training of mechanics allows for a personalized approach at a level that was previously only available through individual work with a production training master.

The theoretical foundations of ITS are reflected in applied STEM platforms, which are actively being implemented in the Ukrainian educational space. As noted by Misyuk, Postova, and Cherniak (2025, pp. 8–11), the digitization of STEM education through adaptive platforms allows for the complete individualization of the learning path of future specialists. In the context of technical training, the authors highlight tools such as Siemens NX Virtual Lab and PTC Creo Simulate for engineering modeling, as well as the Querium system, which provides personalized support in the study of natural and engineering disciplines.

It is important to note that the introduction of these technologies changes the functional profile of teachers. According to Misyuk et al. (2025, pp. 5–12), teachers become intermediaries between the real and virtual worlds, acting as analysts of students' “digital footprints.” A survey of Ukrainian educators confirms a high level of interest in such transformations: 75.8% of respondents have a positive attitude toward the use of AI, and 93.6% express a desire to explore the capabilities of intelligent platforms in greater depth. Thus, the introduction of ITS in the training of mechanics allows for a personalized approach at a level that was previously only available through individual work with a production training master, while ensuring the transparency of learning algorithms and high engagement of the digital generation “Z.”

The introduction of adaptive learning systems radically changes the functional profile of the teacher. As noted by Misyuk et al. (2025, pp. 9–13), in digital education, the teacher ceases to be merely a transmitter of knowledge, becoming instead a mediator between the real and virtual worlds. In the context of training specialists in the automotive industry, where complex simulators and ITS are used, this role becomes even more multifaceted (Table 4.2).

Table 4.2. Transformation of the functional roles of vocational education teachers in the context of the integration of intelligent training systems (ITS)

Traditional Role	New Role in the Digital Environment	Professional Implementation (Automotive Profile)
Source of information	Guide and curator of digital platforms	Expert selection and verification of technical content, updating standards, integration of manufacturers' electronic catalogs.
Knowledge controller	Digital footprint analyst	Analysis of simulator logs (including Siemens NX), identification of typical errors in design and part modeling.
Organizer of learning	Architect of personalized learning pathways	Adjustment of ITS adaptability parameters according to the group's level of preparation; development of individual modules for mastering technical diagnostics.
Motivator	Tutor and professional coach	Support of learners while solving complex cases (engine and electrical system diagnostics).
Lecturer	Designer of digital tools	Development of scenarios for AR instructions, interactive simulators, and digital workshops.
Examiner	Moderator of blended assessment	Integration of AI-based diagnostics results with the assessment of practical activities in real production conditions.
Reproducer of knowledge	Facilitator of problem-based learning	Organization of work with real technical cases from service centers.
Disciplinary supervisor	Manager of digital ethics and academic integrity	Monitoring AI use, prevention of dishonest copying of algorithmic solutions.
Methodologist	Integrator of STEM ecosystems	Alignment of digital modules in mechanics, electronics, and IT into a unified educational system.
Industrial practice mentor	Mentor of professional identity	Formation of responsibility for technical decisions, development of a culture of safe work and professional ethics.

SourceAdapted from Misyuk et al., 2025, pp. 9–13; Woolf, 2022, pp. 380–386.

This transformation of the teacher's role allows for the most effective use of AI's predictive capabilities. According to Misyuk et al. (2025, p. 9), it is the teacher-analyst who is able to interpret the system's recommendations for improving learning outcomes. This is consistent with Woolf's (2022, pp. 384–388) concept of intellectual support: AI takes on the routine diagnosis of gaps, while the teacher focuses on developing critical thinking and solving non-standard engineering problems, which is critical for training digital natives who seek rapid technological implementation.

The implementation of an adaptive approach in Ukrainian vocational education institutions today is closely linked to the development of dual education. As noted by Savchuk et al. (2025), the use of AI in dual education allows for the effective bridging of the "digital divide" and "skills gap" between employer requirements and graduate training.

According to the results of a focus group study conducted by the authors, the greatest potential of AI lies in the personalization of learning and the use of virtual simulators. In particular, 81% of students and 74% of employers surveyed expressed a positive attitude towards the integration of intelligent systems into the learning process. However, teachers and researchers (68%) express concern about the possible replacement of "live" mentors with virtual algorithms, which emphasizes the need to maintain a balance between technology and direct professional experience in the workplace.

Thus, the digitization of vocational education, in particular the introduction of Intelligent Tutoring Systems, is changing not only the tools of learning, but also the very structure of pedagogical activity. While in the traditional paradigm the teacher acted primarily as a carrier and transmitter of knowledge, in the digital educational environment they become the architect of the learning experience.

Unlike the classical model, where knowledge was assessed through oral and written tests, modern ITS accumulate data arrays on the learner's educational activity. In this context, the teacher acts as a digital footprint analyst, interpreting log file data, identifying cognitive "bottlenecks," and adjusting the educational trajectory.

The professional training of students in the automotive field is characterized by a high level of practical intensity and technological complexity. Unlike a number of other industries, where the cognitive-information component dominates, in the field of vehicle maintenance and repair, the formation of operational skills, precision of manual actions, spatial thinking, and the ability to quickly diagnose malfunctions are of key importance. That is why the integration of digital technologies in this field is unique and requires separate consideration.

Modern computer-aided design and modeling systems, such as Siemens NX, as well as virtual diagnostic simulators and interactive trainers, make it possible to reproduce complex technical processes in a safe digital environment. Their use ensures the gradual development of professional competencies without the risk of damage to equipment, injury, or incorrect interference with real technical systems. The digital environment

allows you to repeatedly practice algorithms of actions, simulate typical and atypical production situations, and quickly receive feedback.

At the same time, the effectiveness of such training needs to be critically assessed in terms of the validity of learning outcomes. A fundamental question arises: is the successful completion of virtual tasks a sufficient condition for readiness for real professional activity? Does the correct completion of a digital scenario guarantee the ability to perform high-quality engine repairs, electrical system adjustments, or diagnostics of complex electronic modules in a car?

Even with a high level of detail, digital simulation does not fully reproduce tactile sensations, the specifics of worn parts, the variability of manufacturing defects, or the psychological component of responsibility for the final result of the work. Therefore, there is a need to integrate simulated and real experience into a single pedagogically sound training system.

In this context, the role of the teacher as a moderator of blended learning becomes particularly important. Their activity consists of a comprehensive comparison of the results of digital monitoring with the actual performance indicators of the trainee. In particular, AI diagnostics data, behavioral indicators in the digital environment (frequency of errors, nature of requests for hints, speed of decision-making), the quality of manipulations in the training workshop, and the level of compliance with safety requirements are analyzed.

Thus, digital technologies do not replace the professional expertise of teachers, but require it as a mechanism for integrative assessment. The human factor ensures the correlation between the results of simulation training and real production skills, acting as a guarantor of the quality and safety of professional training.

The introduction of intelligent training systems (ITS) into vocational education leads to significant changes in the structure of pedagogical activity. While the traditional model was dominated by the functions of explanation, control, and reproductive testing of knowledge, the digital environment actualizes the analytical, coordination, and integration aspects of the teacher's work.

ITS systems accumulate significant amounts of data on the educational activity of learners: the sequence of operations, the frequency of errors, the duration of task completion, and the nature of reference material use. This opens up new opportunities for a differentiated approach, but at the same time requires professional interpretation of the information obtained.

The instructor critically analyzes algorithm recommendations, correlating them with specific educational conditions, the level of preparation of the group, and the material and technical base of the institution. They adapt digital tools to the actual contingent of applicants, determine the feasibility of complicating or simplifying learning tasks, and regulate the balance between online and offline components of training.

Thus, the algorithmization of the educational process does not reduce the role of the teacher to technical support for digital systems. On the contrary, it enhances the importance of professional judgment, the ability to integrate heterogeneous data, and ensure the integrity of the educational process. The teacher acts as an interpreter of the results of automated analytics and a coordinator of blended learning, combining simulation with real-life production practice.

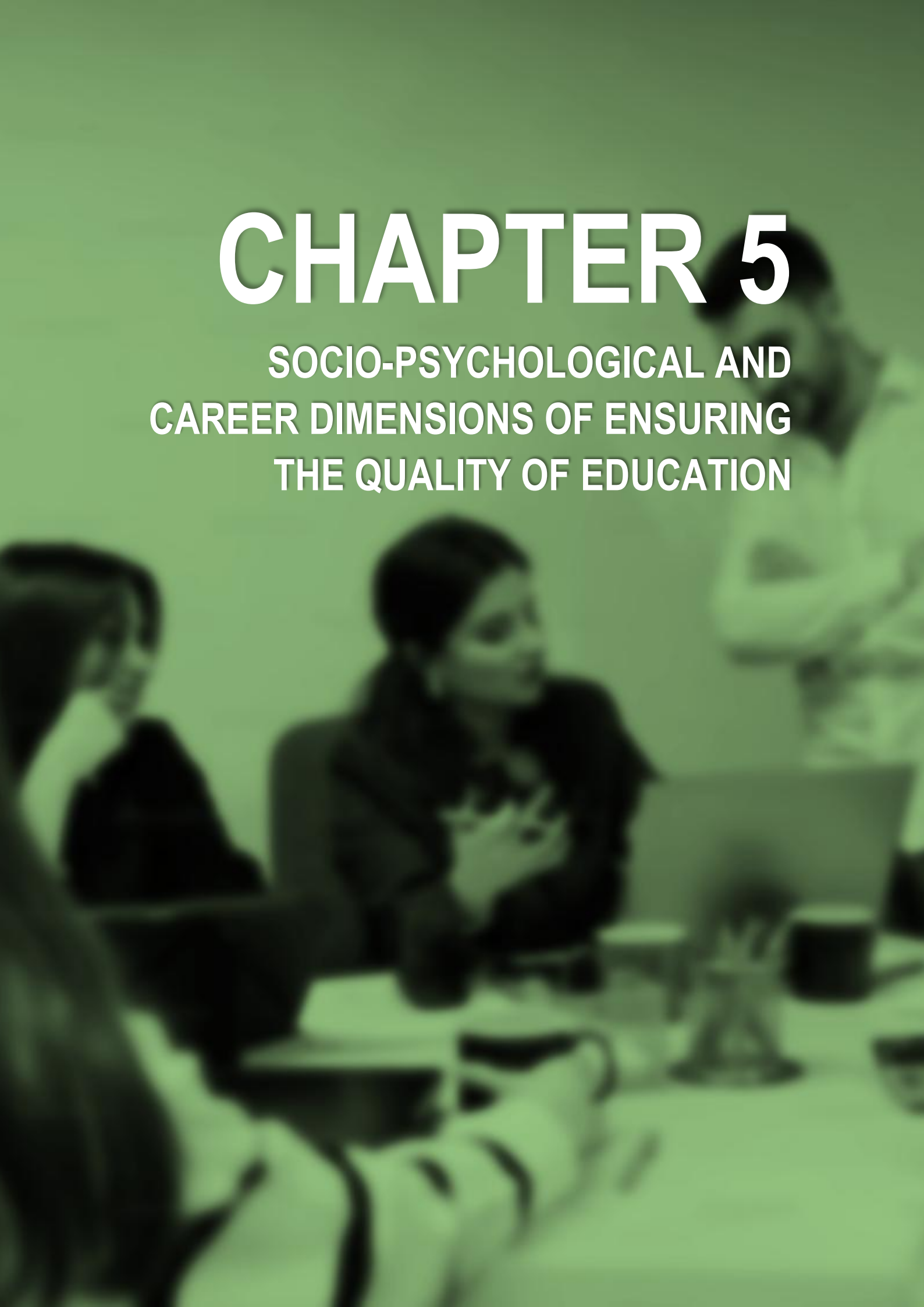
The digital transformation of vocational education brings to the fore not only technological aspects but also value-based aspects of training future specialists. In the field of motor transport services, technical errors can have direct consequences for human safety. Therefore, the development of professional competence must be accompanied by the development of a responsible attitude toward decisions made.

In a digital environment, learners often interact with algorithmic prompts, automated recommendations, and ready-made solutions. This creates the risk of formal assimilation of procedures without a deep understanding of their content. In this regard, pedagogical support aimed at forming a critical attitude towards automatic recommendations and awareness of the limits of artificial intelligence systems is of particular importance.

The instructor emphasizes responsibility for the final result of the work, stresses the importance of compliance with safety standards, and fosters a culture of professional reflection. It is not only about the correct execution of the algorithm, but also about understanding the possible consequences of a technical decision in real-world vehicle operating conditions.

Thus, digital technologies are integrated into the vocational training system not as an autonomous component, but as a tool subordinate to the overall goal of training competent, responsible, and ethically oriented specialists.

The analysis allows us to draw the following conclusions. First, the integration of intelligent learning systems significantly changes the functional structure of the activities of vocational education teachers, expanding their analytical and coordination dimensions. Second, in the field of motor transport training, digital simulations require mandatory verification in a real workshop, which determines the key role of blended learning. Third, the teacher ensures the integration of the results of algorithmic analytics with the practical assessment of the professional actions of applicants, acting as a guarantor of the quality and safety of training. Fourth, the digitization of education actualizes the ethical component of professional training, which is related to responsibility for technical decisions and the critical use of artificial intelligence tools. Fifth, the human factor remains decisive in ensuring the integrity, validity, and practical orientation of the educational process in the motor transport profile.



CHAPTER 5

SOCIO-PSYCHOLOGICAL AND CAREER DIMENSIONS OF ENSURING THE QUALITY OF EDUCATION

5.1. DEVELOPMENT OF TEACHER AGENCY AS A FACTOR IN THE INTERNAL QUALITY ASSURANCE OF VOCATIONAL EDUCATION AND TRAINING

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The section substantiates the role of teacher agency as a fundamental factor in ensuring the quality of vocational education and training in Ukraine amidst post-war recovery and digital transformation. Based on the Law of Ukraine "On Vocational Education" (2025), the study argues for a paradigm shift from the "teacher-executor" model to the "teacher-agent of change" model, characterized by professional autonomy and the capacity to transform the educational environment. The theoretical framework integrates the ecological approach (M. Priestley, G. Biesta), social-cognitive theory (A. Bandura), and the subjective-productive approach. The author conceptualizes teacher agency as an integrated professional characteristic manifesting through three key components: subjective (professional identity and partnership with students), proactive (initiative and innovative design of the learning process), and self-efficacious (resilience and self-regulation in uncertain conditions). The study aligns these components with the European Quality Assurance in Vocational Education and Training framework and the criteria for assessing the quality of educational activities. It is proven that teacher agency acts as a "living driver" of the PDCA cycle (Plan-Do-Check-Act), ensuring that internal quality systems move beyond formal monitoring toward sustainable development. Special emphasis is placed on "co-agency" as a partnership-based relationship where the student is recognized as an active subject of their career trajectory. The findings demonstrate that teacher agency serves as the internal core of educational quality, enabling VET institutions to remain flexible and competitive.

Keywords: *teacher agency, vocational education and training, internal quality assurance, self-efficacy, EQAVET, proactive behavior, subjective-productive approach*

The contemporary transformation of the vocational education system in Ukraine is taking place under unprecedented challenges, driven both by the need for post-war economic recovery and by global demands for digitalization and the greening of labor. In this context, internal quality assurance in education ceases to be merely an administrative process of monitoring and reporting, evolving instead into a dynamic system whose viability directly depends on the active position of the key subject of the educational process – the teacher.

The key concept that enables a renewed understanding of the role of the teacher and the vocational training instructor is "agency" (teacher agency).

Teacher agency is not synonymous merely with professional competence or the ability to fulfill formal job responsibilities. According to the ecological approach, agency is understood as an individual's capacity to consciously and actively influence their professional circumstances, make responsible decisions, and transform the educational environment in accordance with quality objectives (Biesta et al., 2015). For the system of vocational education, this implies a shift from the "teacher-as-performer" model to the "teacher-as-change agent" model, in which educators are capable of adapting curricula to stakeholders' requirements, implementing innovative technologies, and independently adjusting the trajectory of their own professional development.

The foundation for the development of teacher agency lies in Ukraine's modern regulatory and legal framework, which in recent years has undergone significant liberalization in the context of governance decentralization and academic autonomy. The basic Law of Ukraine "On Education" (Verkhovna Rada of Ukraine, 2017a) defines academic freedom as one of the key principles of educational activity, directly correlating with the concept of agency by granting teachers the right to freely choose forms, methods, and instructional tools, as well as to independently determine the content of author-developed curricula. In particular, Article 54 of this Law emphasizes the obligation of teaching staff to continuously enhance their professional level, while at the same time guaranteeing their right to an individual educational trajectory, which serves as a prerequisite for the manifestation of professional subjectivity.

A qualitatively new stage in the development of teacher agency began with the adoption in 2025 of the Law of Ukraine "On Vocational Education", which formalizes the transition from rigid centralization to flexible responsiveness to labor market demands, where teachers and vocational training instructors act as key stakeholders in the development of professional educational programs based on new-generation standards. The 2025 Law de jure legitimizes teachers' professional autonomy by granting them expanded rights in the governance of the educational process through participation in institutional councils and sectoral qualification councils. This establishes an institutional foundation for the manifestation of projective agency, whereby teachers not only transmit established knowledge but also participate in forecasting future needs for professional skills (Verkhovna Rada of Ukraine, 2025c).

In parallel, the field of professional pre-tertiary education continues to be regulated by the Law of Ukraine "On Professional Pre-Tertiary Education" (2019b), which introduced the concept of an internal quality assurance system in education. In combination with the provisions of the Law of Ukraine "On Vocational Education", a unified legal framework is being formed in which the quality of education is determined not by the number of inspections, but by the capacity of the teaching staff for self-organization and innovation. In particular, the 2025 legislation promotes the development

of partnerships with business, which requires a high level of teacher agency to ensure effective communication with employers and the integration of industry standards into the curriculum.

An important lever for stimulating the development of teacher agency has been the Resolution of the Cabinet of Ministers of Ukraine "Some Issues of Professional Development of Pedagogical and Academic Staff" No. 800 (Verkhovna Rada of Ukraine, 2019c). This document fundamentally transformed the paradigm of professional development by allowing educators to independently choose providers of educational services, which constitutes a direct manifestation of retrospective agency – the capacity to draw upon past experience in order to design future professional growth.

Thus, Ukraine's contemporary regulatory framework has evolved from procedural regulation toward supporting the subjectivity of teachers as the primary guarantors of the quality of vocational training.

In the global academic and educational discourse, teacher agency is regarded not merely as an individual characteristic of an educator, but as a fundamental mechanism for ensuring the sustainability and quality of educational systems. A key conceptual document in this context is the OECD Learning Compass 2030, in which agency is defined as an individual's capacity to set goals consciously, reflect, and act responsibly in order to bring about positive change (OECD, 2018, p. 4). The Organisation for Economic Co-operation and Development emphasizes that in the context of rapid technological transformations, the internal quality of vocational education depends on "co-agency", whereby the teacher functions not as a mere transmitter of standards, but as an active architect of the educational environment, capable of adapting the learning process to students' individual needs and to labor market demands.

An important milestone in rethinking the role of the teacher was the UNESCO report Reimagining Our Futures Together: A New Social Contract for Education. The document emphasizes that ensuring the quality of education in the twenty-first century is impossible without recognizing teachers as key participants in the development of educational policy (UNESCO, 2021). The United Nations Educational, Scientific and Cultural Organization underscores that teacher agency should be realized through collective collaboration and autonomy, enabling professional communities to independently adjust curricular content in response to global challenges. Such an approach transforms the understanding of the internal quality assurance system: it ceases to function as an instrument of external control and instead becomes the outcome of the conscious professional activity of teachers as agents of change.

At the level of the European Union, strategic guidelines for the development of agency are embedded in the European Education Area initiative. In particular, the Digital Education Action Plan (2021–2027) conceptualizes teacher agency through the lens of

educators' capacity to critically select and implement digital tools, which is especially crucial for professional pre-tertiary and vocational education (European Commission, 2021). Furthermore, the Reference Framework of Competences for Democratic Culture of the Council of Europe links agency to the development of autonomy and responsibility, asserting that a teacher with a high level of subjectivity serves as a guarantor of an inclusive and high-quality educational environment (Council of Europe, 2018). Thus, an analysis of international documents demonstrates that teacher agency constitutes a global standard and a necessary condition for the transition from formal to substantive quality assurance in education.

In the contemporary paradigm of educational management, the internal quality assurance of vocational and professional pre-higher education is viewed not merely as a set of regulated procedures, but as a complex socio-pedagogical ecosystem in which human capital and the intellectual potential of staff serve as key stabilizing factors (Radkevych, 2024, p. 4). A theoretical and methodological analysis of scholarly research indicates that the effectiveness of this system directly depends on the level of teachers' professional agency, which determines their ability to transform institutional requirements into high-quality educational outcomes (Priestley et al., 2015). In this context, agency is defined as a systemic quality factor that integrates a teacher's capacity for strategic goal-setting, the exercise of professional autonomy, and the responsible transformation of the educational environment.

A systematic analysis of teacher agency as a holistic phenomenon is made possible through the application of a four-level methodological vertical: from the fundamental laws of self-organization of educational systems to the specific psychological and pedagogical mechanisms of its implementation in productive activity. We structure the methodological apparatus across four levels: general scientific, conceptual-theoretical, professional-contextual, and pragmatic-technological.

At the general scientific level, the synergetic approach is leading, as it allows the internal quality assurance system of education and the teacher's professional position to be considered as open, nonlinear systems that exist in a state of continuous self-development. Within this approach, teacher agency appears as a powerful internal resource – a point of fluctuation. At moments of critical instability of the educational system, defined as bifurcation points (for example, periods of radical reforms, digitalization, or crisis transformations of the labor market), the system becomes extremely sensitive to individual initiatives.

The connection between these categories is manifested in the fact that it is precisely the teacher's agentic action (a fluctuation) at the bifurcation point that determines the vector of further movement of the entire institutional system: either toward progressive development and qualitative renewal, or toward stagnation. Thus, agency

becomes the microscopic factor that triggers macroscopic changes in the quality of vocational education. As Radkevych (2024, p. 9) emphasizes, under conditions of unpredictability and complex challenges, it is the self-reliance of the specialist as the capacity for constructive self-development, professional initiative, and the self-organization of the teaching staff that enable the system not merely to survive, but to make a qualitative leap, adapting to the demands of contemporary society.

At the conceptual-theoretical level, the study is based on the integration of the subject-action and socio-cognitive approaches. The subject-action approach (Tatenko, 2017) reveals the ethical and psychological nature of agency through the category of the act as a unit of analysis of human activity. A teacher becomes a genuine agent of quality only when he or she makes a responsible professional choice, acting as the author of his or her own existence. This approach is complemented by Bandura's (2001, pp. 1–5) social cognitive theory, which substantiates the mechanism of self-efficacy. A teacher's belief in his or her own ability to influence learning outcomes serves as the internal driving force that transforms potential subjectivity into real professional activity.

The professional-contextual level of the methodology is implemented through ecological and interdisciplinary approaches. The ecological approach (Priestley, Biesta and Robinson) emphasizes that agency is not an innate trait but is "achieved" through interaction with a specific environment – material resources, institutional culture, and structural opportunities (Priestley et al., 2015). The interdisciplinary approach, in turn, makes it possible to integrate the demands of the high-tech labor market with the psychological and pedagogical aspects of specialist training, which is crucial for institutions of vocational and professional pre-higher education (Radkevych, 2024).

At the pragmatic-technological level, the subject-productive approach, conceptualized in the works of H. Romanova, is central. This approach focuses teacher agency on the final product of activity - the quality of training of a competitive graduate. According to Romanova (2012), the development of teacher subjectivity is a prerequisite for the successful design of an educational process oriented toward the productive self-realization of the learner. It is at this level that agency is transformed into specific career guidance methodologies and internal quality audit tools.

The connection between teacher agency and the internal quality assurance system of vocational education (IQAS) is not only functional but also determinative in nature. In contemporary scholarly discourse, the quality of education is interpreted as the degree of alignment with continuously updated goals. Under such conditions, agency becomes the primary instrument for maintaining this alignment. Drawing on the ecological approach, we substantiate that the quality of vocational education is "achieved" through a teacher's ability to critically assess available resources (for example, the material and technical base of an educational institution or a vocational training and practice center) and to adapt

them to learners' individual educational trajectories (Priestley et al., 2015). This transforms the teacher from a passive implementer of standards into an active "quality guarantor" at the level of a specific lesson or workplace-based training.

From the perspective of the subject-productive approach, the quality of vocational education directly depends on the productive orientation of the teacher's agentic action. This means that the internal quality assurance system becomes effective only when it is integrated into the professional subjectivity of the teacher, stimulating the creation of innovative educational products – authorial programs, digital content, and career mentoring systems (Romanova, 2025). Thus, agency performs the role of a quality regulator: it enables the timely identification of educational risks (for example, a mismatch between a learner's skills and employer requirements) and their proactive mitigation.

Therefore, the theoretical and methodological substantiation allows us to assert that teacher agency constitutes the internal "core" of the quality system. Within a synergetic logic, it functions as a mechanism of self-correction of the educational process: through agentic micro-fluctuations (individual pedagogical initiatives), the institutional system as a whole acquires the properties of flexibility and competitiveness. This ensures the transition from "quality of control" to "quality of development," where each teacher perceives himself or herself as a subject whose activity directly influences the graduate's career success and the prestige of the vocational education institution.

The study of the phenomenon of teacher agency in contemporary psychological and pedagogical science has evolved from the analysis of individual manifestations of professional activity to the formation of holistic ecological and subject-oriented models. An analysis of the scholarly literature indicates that the roots of the concept lie in the works of the founders of social cognitive theory, in particular Bandura, who was the first to substantiate agency as an individual's capacity for intentional influence on the events of his or her life through mechanisms of forethought and self-regulation. In his research, emphasis is placed on cognitive structures of self-belief that determine an individual's motivation and actions (Bandura, 2001, pp. 1–26).

The further development of the concept is associated with a shift from a purely psychological to a socio-ecological interpretation. A significant contribution to this process was made by Priestley, Biesta, and Robinson, who developed an ecological model of teacher agency. In their studies, agency is viewed not as a fixed personal trait but as a "processual achievement" made possible through the interaction of a teacher's individual efforts with the cultural and structural resources of the educational institution (Priestley et al., 2015). Issues of professional autonomy and a teacher's capacity to influence educational policy through an agentic position were also explored by Vähäsantanen and

Eteläpelto, who focused on the relationship between agency, professional identity, and workplace learning (Eteläpelto et al., 2013, pp. 57–61).

Examining the phenomenon of agency in the context of vocational education and training, Vähäsantanen emphasizes its temporal nature and its inseparable connection with professional identity. Agency is considered not only as an instrument for implementing educational reforms, but as the way in which a teacher aligns his or her professional position with the dynamic demands of the external environment and the internal quality assurance system (Vähäsantanen, 2015).

For a deeper understanding of the essence of teacher agency, it is advisable to turn to the critical analysis of multidisciplinary approaches proposed by a group of researchers led by Eteläpelto et al. (2013, pp. 48–57). The authors argue that the contemporary conceptualization of professional agency at work has developed at the intersection of four key scientific traditions:

- the social-scientific tradition, where agency is examined in dichotomy with "structure"; the main focus is on how socio-economic conditions and institutional frameworks (in our context, regulatory quality requirements) constrain or, conversely, serve as resources for a teacher's individual action;
- the post-structuralist tradition, which focuses on the role of discourse and power; within this approach, teacher agency is studied as the capacity to resist formalized systems of control and to reconfigure professional identities within existing power relations in an educational institution;
- the sociocultural approach, which is the most relevant for vocational education, as it considers agency as mediated activity; the teacher uses cultural tools, technologies, and interaction with colleagues to transform the educational environment;
- the professional identity and life-course approach, where agency is understood as the way a teacher constructs his or her career and professional "self" over time, making strategic decisions within specific historical circumstances (Eteläpelto et al., 2001, pp. 48–57).

Synthesizing these traditions, Eteläpelto proposes a subject-centered sociocultural perspective that serves as a methodological bridge for our study. Its key thesis is that agency is not abstract activity – it always belongs to a specific subject with unique experience, emotional involvement, and professional intentions. This allows us to assert that within the internal quality assurance system of vocational education, teacher agency is realized as a complex interaction between individual subjectivity and the organizational context of the institution.

In the Ukrainian scholarly field, the problem of teacher agency and subjectivity has gained particular relevance in the context of the modernization of vocational education. Fundamental aspects of the subject-action determination of professional

activity are revealed in the works of Tatenko, where the teacher appears as an active creator of his or her professional existence. Issues related to the development of subjectivity as the basis for professional training are actualized by Romanova, who substantiates the subject-productive approach to designing the educational process (Romanova, 2012).

Particular importance in the national scholarly tradition has been attached to research on agency as a factor in the professional self-determination of youth, conducted at the Institute of Vocational Education of the National Academy of Educational Sciences of Ukraine. Issues of career counseling and the formation of learners' career competence through the prism of active pedagogical action are highlighted in the works of Zakatnov et al. (2019). Yershova emphasizes the phenomenon of a teacher's self-reliance as a critical component of their professional agency in crisis conditions (2024).

Thus, the current state of research is characterized by a shift toward the integration of psychological (internal) and structural (external) factors, which makes it possible to consider teacher agency as a multidimensional construct. For a deeper understanding of the essence of the concept, it is advisable to conduct a content analysis of existing definitions in order to synthesize an authorial definition of agency in the context of ensuring the quality of vocational education.

The study of teacher agency within the internal quality assurance system of vocational education requires resolving a certain terminological discussion. Given the complexity of this phenomenon, we propose considering agency as an umbrella concept. This approach makes it possible to integrate into a single theoretical framework both direct definitions of "agency" (primarily presented in Western scholarly discourse) and related categories such as "subjectivity," "professional mobility," and "self-reliance," which constitute the fundamental content of teacher activity in the Ukrainian psychological and pedagogical tradition.

In order to clarify the essential characteristics of agency, a comparative analysis of key definitions and substantive components of this phenomenon was conducted, the results of which are presented in Table 5.1.

Table 5.1. Content Analysis of Essential Characteristics and Substantive Components of Teacher Agency (N=21)

No	Author (Researcher)	Category	Content (in the context of teacher agency)	Bibliographic reference
1.	Goller, M., & Paloniemi, S.	Professional Agency	Definition of agency as the ability of an individual to make choices and act to control professional life; integration of different research approaches.	Goller & Paloniemi, 2017

Table 5.1. Content Analysis of Essential Characteristics and Substantive Components of Teacher Agency (N=21)

No	Author (Researcher)	Category	Content (in the context of teacher agency)	Bibliographic reference
2.	Bandura, A.	Self-efficacy	Fundamental theory of self-efficacy as belief in one's own capability to act.	Bandura, 1997
3.	Bandura, A.	Agentic perspective	Social cognitive theory of agency as a mechanism of personal self-regulation.	Bandura, 2001
4.	Biesta, G. & Tedder, M.	Agency	Understanding agency as a way of constructing a life course through learning.	Biesta & Tedder, 2007
5.	Biesta, G., Priestley, M., & Robinson, S.	Teacher agency	Influence of teachers' value orientations and beliefs on their professional agency.	Biesta et al., 2015
6.	Eteläpelto, A., Vähäsantanen, K., Hökkä, P., & Paloniemi, S.	Professional agency	Conceptualization of professional agency as the capacity to influence the work environment.	Eteläpelto et al., 2013
7.	Yershova, L. M.	Self-reliance	Teacher resourcefulness in crisis conditions as a manifestation of professional agency.	Yershova, 2024
8.	Hökkä, P., Vähäsantanen, K., Paloniemi, S., & Eteläpelto, A.	Emotions & Agency	Interrelation between a teacher's emotional state and the capacity to demonstrate agency in the workplace.	Hökkä et al., 2017
9.	Zakatnov, D. O., Alieksieieva, S. V., Velychko, N. O., Yershova, L. M., Kuzminska, L. D., Lozovetska, V. T., & Orlov, V. F.	Career counseling	Systematic activity of a teacher-agent in supporting learners' career success.	Zakatnov et al., 2019
10.	Lent, R. W., Brown, S. D., & Hackett, G.	Contextual Agency	Analysis of external supports and barriers influencing the realization of agency in career choice.	Lent et al., 2000

Table 5.1. Content Analysis of Essential Characteristics and Substantive Components of Teacher Agency (N=21)

No	Author (Researcher)	Category	Content (in the context of teacher agency)	Bibliographic reference
11.	Norton, M. I., Mochon, D., & Ariely, D.	Contribution to outcome	Psychological reinforcement of agency through awareness of the value of one's own work.	Norton et al., 2011
12.	Quinn, R., & Carl, N. M.	Student agency	Agency as the ability to take responsibility for lifelong learning.	Quinn & Carl, 2015
13.	Quinn, R., & Carl, N. M.	Professional agency	Agency as the ability to control professional activity within structural constraints and through collective action.	Quinn & Carl, 2015
14.	Pantic, N.	Agency for justice	Teacher agency as an instrument for ensuring social justice and educational quality.	Pantic, 2015
15.	Priestley, M., Biesta, G., & Robinson, S.	Teacher agency	Ecological approach: agency as a dynamic professional achievement.	Priestley et al., 2015
16.	Romanova, G. M.	Teacher agency	Agency as an integral characteristic of teacher professional performance quality.	Romanova, 2025
17.	Stajkovic, A. D.	Efficacy & Agency	Relationship between individual self-efficacy and agentic behavior in organizations.	Stajkovic, 2006
18.	Tschannen-Moran, M.	Teacher efficacy	Specificity of teacher self-efficacy and its impact on student learning outcomes.	Tschannen-Moran, 2001
19.	Vähäsantanen, K.	Identity agency	Understanding educational change through professional agency and identity development.	Vähäsantanen, 2015

Table 5.1. Content Analysis of Essential Characteristics and Substantive Components of Teacher Agency (N=21)

No	Author (Researcher)	Category	Content (in the context of teacher agency)	Bibliographic reference
20.	Vähäsantanen, K.	Vocational teachers' professional agency	Researching the agency of vocational education teachers as the capacity to influence work and develop professional identity under conditions of change.	Vähäsantanen, 2013
21.	Zimmerman, B. J.	Self-regulated agency	Agency through processes of self-regulation and belief in professional success.	Zimmerman, 2000

The generalization of the results of the conducted analysis allows us to synthesize a definition adapted to the context of vocational education.

By *teacher agency* we understand an integral professional and personal characteristic manifested in the capacity for conscious and proactive influence on the educational process, transformation of the professional environment on the basis of subjectivity and self-reliance, realized through a partnership-based attitude toward learners as active subjects of their own learning and aimed at ensuring high-quality training and their future career success.

It is important to emphasize that within this approach the learner ceases to be an object of pedagogical influence and becomes an active partner in designing his or her own career. Thus, the agentic action of the teacher has a dual orientation: toward the improvement of the institution’s internal quality assurance system and toward facilitating the professional development of the student’s personality. Such a definition shifts the emphasis from the passive performance of functional duties to the authorial role of the teacher within the internal quality assurance system.

The formulated understanding of teacher agency as an integral characteristic presupposes its dynamic unfolding across the temporal continuum of professional activity. Drawing on the ecological approach (Priestley et al., 2015), we argue that agency includes three interrelated dimensions that ensure the continuity of educational quality:

- projective, which determines the teacher’s orientation toward the future through the ability to analyze industry development prospects and labor market demands, transforming them into strategic learning goals and models of the learner’s future professional success;
- retrospective, which consists in the reflective use of previous professional and pedagogical experience for the selection and implementation of the most effective methods of influencing the educational process;

- practical–evaluative, manifested in the specialist's capacity to act in specific circumstances "here and now," flexibly adjusting career guidance measures and instructional strategies depending on the dynamics of progress and the level of student motivation.

This temporal triad enables the teacher not only to adapt to change but also to act as an active designer of educational quality. The combination of these dimensions ensures the stability of the quality system: retrospection provides stability, projection offers a vector of development, and operational action ensures responsiveness to learners' needs.

The synthesis of theoretical approaches allows us to define the internal architecture of the phenomenon under study through the unity of the following components:

- subjective component, which serves as the value-based core of agency grounded in professional identity and a conscious partnership-oriented attitude toward learners as active subjects of their own learning;
- proactive component, functioning as the dynamic driving force of agency, manifested in the teacher's capacity for anticipatory action, initiation of innovative changes, and independent design of the educational environment in accordance with labor market demands;
- self-reliant component, representing the regulatory and result-oriented element of agency, based on the specialist's confidence in his or her ability to effectively solve complex professional tasks and ensure stable quality of educational support under conditions of uncertainty.

The proposed structure demonstrates that teacher agency is not a sum of separate qualities but functions as an integrated system: subjectivity provides ethical meaning to action, proactivity offers a strategic vector, and self-reliance ensures practical effectiveness. It is precisely this configuration of components that enables the teacher to act as a genuine subject of the internal quality assurance system of vocational education, capable of flexibly responding to the career needs of each learner.

In the contemporary paradigm of vocational education development, the issue of quality shifts from the sphere of purely formal control to that of dynamic professional development. The methodological foundation of this process is the European Quality Assurance Reference Framework for Vocational Education and Training (EQAVET), which considers quality as a cyclical process based on the sequence of planning, implementation, evaluation, and review of educational activities (European Commission, 2026c). Within this framework, teacher agency is particularly crucial at the stage of review and adjustment, since the proactive position of the specialist enables the transformation of monitoring results into real changes in educational practice.

At the national level, these principles are normatively enshrined in the Methodological Recommendations for the Formation of an Internal Quality Assurance System in Vocational (Vocational-Technical) Education Institutions, approved by Order of the Ministry of Education and Science of Ukraine No. 509 of May 6, 2021. According to this document, the development of the internal quality system directly depends on the active position of the teacher, particularly within the domain of "Pedagogical Activity," where the emphasis shifts from control to supporting the learner's personal progress (Verkhovna Rada of Ukraine, 2021a).

In the context of the criteria defined by the Ministry, teacher agency is manifested through the capacity to implement formative assessment to track individual learning trajectories, to foster responsible attitudes toward learning by providing necessary support, and to ensure active self-assessment of learners through peer assessment techniques. Thus, teacher agency constitutes the integral factor that enables vocational education institutions not merely to formally comply with the requirements of Order No. 509, but to transform these indicators into viable educational outcomes. The substantiation of agency as a quality factor is based on the reciprocal relationship between teachers' internal dispositions and the effectiveness indicators of the educational process, reflected in the correlation of agency components with quality dimensions (see Table 5.2).

Table 5.2. Comparison of the Components of Teacher Agency with Quality Aspects in Vocational Education Institutions

Component of Agency	Component Description	Quality Aspect	Impact on the Quality Assurance System
Subjective	Professional identity, value orientations, humanistic attitude toward learners as subjects of learning, awareness of the purpose of professional activity.	Quality of educational programs and student-centeredness	Contributes to the creation of a partnership-based environment where learners' needs form the basis for adapting educational content and individualizing learning.
Proactive	Ability for anticipatory action, initiative, implementation of innovations.	Quality of the educational process and teaching	Transforms passive learning into activity-based learning, ensuring high effectiveness in the acquisition of competencies.

Table 5.2. Comparison of the Components of Teacher Agency with Quality Aspects in Vocational Education Institutions

Component of Agency	Component Description	Quality Aspect	Impact on the Quality Assurance System
Self-reliant	Belief in one's own capability (self-efficacy), self-regulation, adaptability.	Sustainable development and professional growth	Ensures continuous self-improvement of the teacher and resilience in the face of reforms and crises.

The analysis of the table makes it possible to conclude that the subjective component of agency constitutes the fundamental basis of quality. A teacher in a vocational education institution who perceives themselves as an agent of change does not merely follow the curriculum but critically reinterprets its content, making it relevant to the learner. This directly affects the indicator of "Relevance of learning" within the framework of EQAVET.

The proactive component determines the instrumental quality of education. It is through proactivity that the transition from theoretical instruction to practice-oriented methodologies and technologies (dual education, project-based learning) is realized. The agentic action of the teacher creates the very "personalized learning environment" that OECD (2018, p. 4) defines as a necessary condition for preparing future-ready professionals.

Finally, the self-reliant component, grounded in self-efficacy theory (Bandura, 1997), performs a stabilizing function in ensuring quality. A high level of self-efficacy enables vocational education teachers to overcome professional barriers and actively participate in internal audits, transforming the procedure of "quality assessment" into a tool for professional growth.

Therefore, the development of teacher agency is not only a condition for personal professional growth but also a strategic factor in ensuring the quality of vocational education. The teacher as an agent becomes a living driver of the continuous quality improvement cycle, ensuring flexibility, adaptability, and effectiveness of vocational education institutions in the face of contemporary challenges.

5.2. METHODOLOGICAL BASIS OF THE CARRIER GUIDANCE AND CAREER COUNSELING IN THE SYSTEM OF INTERNAL QUALITY ASSURANCE IN EDUCATION

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The section explores the methodological foundations of career guidance and counseling within the internal quality assurance system (IQAS) of vocational education in Ukraine. Contemporary socio-economic challenges, including war-related labor market disruptions, migration, and post-war reconstruction, necessitate a systemic approach to supporting learners' professional self-determination. The study emphasizes the integration of career guidance into IQAS as a strategic tool for aligning educational programs with labor market demands, enhancing graduate employability, and fostering lifelong career development. Methodologically, the research is grounded in systemic, competency-based, learner-centered, activity-oriented, axiological, and evidence-based approaches. The proposed model incorporates target, content, organizational-process, diagnostic-monitoring, and outcome components, ensuring a comprehensive framework for professional trajectory planning and evaluation. The findings highlight the role of career guidance in developing career competence, promoting adaptability, and strengthening the connection between vocational education institutions, employers, and labor market realities. This approach aligns European best practices with Ukraine's national context.

Keywords: *career guidance, vocational education, internal quality assurance, employability, career competence*

The current stage of development of the national vocational education system is characterized by profound structural changes in the labor market caused by war-related challenges, demographic losses, large-scale migration processes, digitalization, and economic transformations, including shifts in the occupational structure of employment. According to official data from the Ministry of Finance of Ukraine, the number of registered unemployed in February 2026 exceeded 93,000 (Ministry of Finance of Ukraine, 2026); however, according to independent social research, this figure amounted to over 12% (Popov, 2025), which significantly exceeds the corresponding pre-war indicators. Overall labor market activity remains lower compared to the period before the full-scale invasion. These phenomena significantly affect the mechanisms of vocational self-determination of learners, highlighting the objective need to integrate career guidance and counseling into the internal quality assurance system of education.

We believe that systematic monitoring of employment and unemployment, taking into account international standards, will contribute to a more thorough understanding of the realities of vocational education graduates transitioning into professional activity and evaluating the effectiveness of educational programs. According to the published data of the State Employment Service of Ukraine (n.d.), in 2025, youth employment dynamics (under 35 years old) were low: out of almost 98,000 young job seekers, only 39,000 (less than 40%) managed to find employment. At the same time, despite a relatively high unemployment rate (12%), there remains an acute shortage of qualified workers in several sectors (over 75% of employers report a strong need for specialists in technical and production professions) (Radkevych & Pryhodii, 2025).

Thus, monitoring studies show a growing number of vacancies and resumes, and labor market activity is gradually approaching pre-war levels, although it has not yet fully reached them (Kuzenkova, 2026). The causes of the persistent acute labor shortage in certain professional segments include structural mismatches between workforce training and economic needs, territorial imbalances, mobilization processes, and large-scale population migration.

Socio-economic realities, particularly the systemic gap between educational preparation and labor market needs, as well as the expected post-war reconstruction processes, necessitate a reconsideration of the role of career guidance and counseling. In conditions of uncertain professional trajectories, traditional approaches to vocational guidance are insufficient, as they are mostly focused on a one-time choice of profession rather than fostering career flexibility, adaptability, and lifelong learning capacity.

The European vector of vocational education development emphasizes the priority of developing flexible skills, forecasting labor market needs, and implementing systems for continuous career support. Within the European Vocational Education Space, career guidance is integrated into lifelong learning and lifelong guidance policies, which ensure systematic, accessible, and evidence-based career support (European Commission, 2020). CEDEFOP analytical materials emphasize that an effective career guidance system in vocational education should be based on the combination of three components: labor market analytics (skills intelligence), individual counseling, and mechanisms for tracking graduates' career trajectories (Cedefop, 2020).

In the Ukrainian context, the modernization of vocational education is being carried out amid war-related challenges, a structural shortage of skilled workers, and the need for post-war economic reconstruction (Radkevych, 2025b). Contemporary educational policy in Ukraine, particularly in the context of implementing the provisions of the Law of Ukraine "On Education" and internal quality assurance standards, prioritizes orienting the educational process toward the needs of learners, as well as the development of their competencies and competitiveness.

In this context, career guidance and counseling are emerging not as auxiliary areas of upbringing or socio-pedagogical activity but as an integrated component of the internal quality assurance system (IQAS), acquiring the status of a strategic tool for improving the quality of education. This reinforces the role of career guidance as a mechanism for aligning educational programs with the projected needs of the labor market. Accordingly, the integration of the above-mentioned processes into the internal quality assurance system of vocational education enables:

- the development of learners' awareness regarding their professional choices;
- an increase in employment rates among graduates of vocational education institutions;
- strengthening of partnership relations, including feedback mechanisms between employers and educational institutions;
- the use of up-to-date career trajectory monitoring data as an important indicator of educational program effectiveness.

Thus, in the context of post-war transformation of the national economy, career guidance and counseling should be considered not as auxiliary aspects of educational or socio-pedagogical work, but as an integrated component of the internal quality assurance system of vocational education, which ensures the preparation of competitive specialists and the adaptability of the educational system to the dynamics of the domestic labor market.

The methodological basis of this study is defined by systemic, competency-based, learner-centered, activity-oriented, axiological, and evidence-based approaches. In particular, the systemic approach is considered fundamental (Aparicio et al., 2021). Guided by the principles of general systems theory, the methodology of this approach allows for understanding career guidance as a subsystem within the internal quality assurance system that interacts with other structural components of a vocational education institution.

According to the European Quality Assurance Reference Framework for Vocational Education and Training (EQAVET), quality is defined through a cyclical model of planning, implementation, evaluation, and review (European Commission, 2026b). From a systemic perspective, the process under study is viewed as an integrated entity with structural components, functional relationships, internal developmental logic, and correlations with the external socio-economic environment. Considering this logic, career guidance should be understood as an element of the educational process stages: planning (considering labor market needs), implementation (individual educational trajectories), and evaluation (employment monitoring) in vocational education institutions. This provides a solid foundation for determining the structural components

of a model representation of career guidance, establishing their hierarchy, and justifying correlational relationships and corresponding mechanisms.

Of particular importance in the context of our study is the competency-based approach, which is grounded in the concept of professional competence (Weigel et al., 2007), aligns with current trends in education modernization, and directs the vocational education system toward developing integrated learning outcomes in learners, including career competence. Career competence is understood as the ability to make informed professional choices, plan professional development, and adapt to changes in the labor market. The theoretical foundations of the competency paradigm are reflected in documents of the European Parliament and the Council of the European Union regarding key competencies for lifelong learning. The OECD emphasizes that career competence is a key component of human capital and enhances individuals' resilience to economic fluctuations (OECD, 2021). Within this study, this approach provides the basis for defining criteria and indicators of career guidance effectiveness and for specifying the expected educational outcomes, particularly the career competence of future specialists.

The learner-centered approach is based on humanistic psychology (Cornelius-White, 2007) and the theory of career development (Savickas, 2013, pp. 148–151), which recognize the agency of the learner, consider their individual educational needs, professional intentions, and value orientations – that is, the active role of the learner in the process of professional self-determination. This approach focuses on taking into account the individual abilities, interests, and values of future specialists. In the context of vocational education, it implies a shift from a directive model of professional selection to a model of collaborative counseling. Applying this approach in justifying the methodological foundations of career guidance and counseling within the internal quality assurance system allows for the development of tools aimed not only at measuring cognitive indicators but also at diagnosing motivational-value and reflective domains.

The activity-based approach, grounded in the cultural-historical theory of psychological development and activity theory (Bulgakova et al., 2025), enables viewing the development of a future specialist's personality as an active interaction with social and professional environments, and consciousness as formed through and in activity. According to this approach, the professional development of vocational education learners is a process of active engagement with educational and production environments – that is, the gradual mastery of action methods, professional behavior norms, and self-regulation mechanisms while performing real or simulated professional tasks of situational relevance. Within vocational education, this entails a shift from reproductive knowledge acquisition toward the development of the ability to act, make decisions, take responsibility for outcomes, and engage in professional reflection. In the context of justifying the methodological foundations of career guidance and counseling within the

internal quality assurance system, the activity-based approach underlies the use of tools aimed at diagnosing practical skills, the ability to make professional choices, plan career trajectories, and readiness for continuous professional development. It involves employing methods that capture actual modes of action, the level of practical skill formation, and the capacity for professional self-development (e.g., case methods, situational modeling, achievement portfolios, reflective journals) along with formative assessment procedures.

The axiological approach is based on the philosophy of values and the humanistic tradition of education (Smyrnova et al., 2021), which view the individual as both a bearer and creator of value-based meanings that shape their behavior, life choices, and professional decisions. Within this approach, career guidance and counseling are considered not merely as informational or advisory processes but as mechanisms for developing a value-based attitude toward work, profession, social responsibility, and self-realization. Applying the axiological approach within the internal quality assurance system of vocational education implies integrating ethical, socio-cultural, and civic dimensions into the content and assessment procedures. This involves considering not only the learner's level of awareness about professions but also the development of professional intentions, motivation resilience, value orientations toward work, entrepreneurial spirit, and responsible attitudes toward career choices. Thus, the axiological approach enables understanding professional education as a process of forming a value-based attitude toward work, profession, and social responsibility. It integrates the humanistic orientations of education and supports the identification of appropriate indicators within the assessment criteria structure. Methodologically, this approach allows for the development of diagnostic tools aimed at identifying the hierarchy of professional values, life-meaning orientations, and the level of awareness of the social significance of the chosen professional trajectory.

The evidence-based approach emerged within the broader paradigm of evidence-based policy, initially developed in medical research (Sackett et al., 1996) and later adapted to the educational field (Slavin, 2002). In the area of career counseling, this approach has been advanced by European researchers (Watts, 2006; Brown & Bimrose, 2014) and analytical documents from OECD and CEDEFOP, which emphasize the need to assess the effectiveness of career interventions based on empirical data. This approach involves using empirical data on employment outcomes, career mobility, and the alignment of qualifications with employer needs. According to OECD (2021), the effectiveness of career guidance systems increases with the regular collection and analysis of data on graduates' transitions from education to employment. Therefore, the evidence-based approach entails making managerial and methodological decisions based

on empirical data (Sackett et al., 1996; Slavin, 2002) and evaluating the effectiveness of career interventions (Watts, 2006; Brown & Bimrose, 2014; Hooley et al., 2011).

Thus, the methodological foundations of career guidance and counseling within the internal quality assurance system can be understood as a comprehensive psychological and pedagogical support for designing educational and career trajectories, taking into account the age-related and individual-personal characteristics of future specialists. These characteristics are established through the use of relevant psycho-pedagogical diagnostic tools and are integrated into the educational environment, the professional activities of educators, and the system of assessing learning outcomes of students. This integration ensures informed career choices and the subsequent development of professional trajectories.

The comprehensive integration of the aforementioned approaches ensures the methodological coherence of our study, defines its guiding principles (such as scientific rigor, systemicity, integrativeness, practical orientation, and variability), and also determines the choice of theoretical, empirical, and statistical methods. Thus, the methodological foundations of the research form a conceptual framework for developing a model, criteria, indicators, and diagnostic tools for career guidance and counseling within the internal quality assurance system of education.

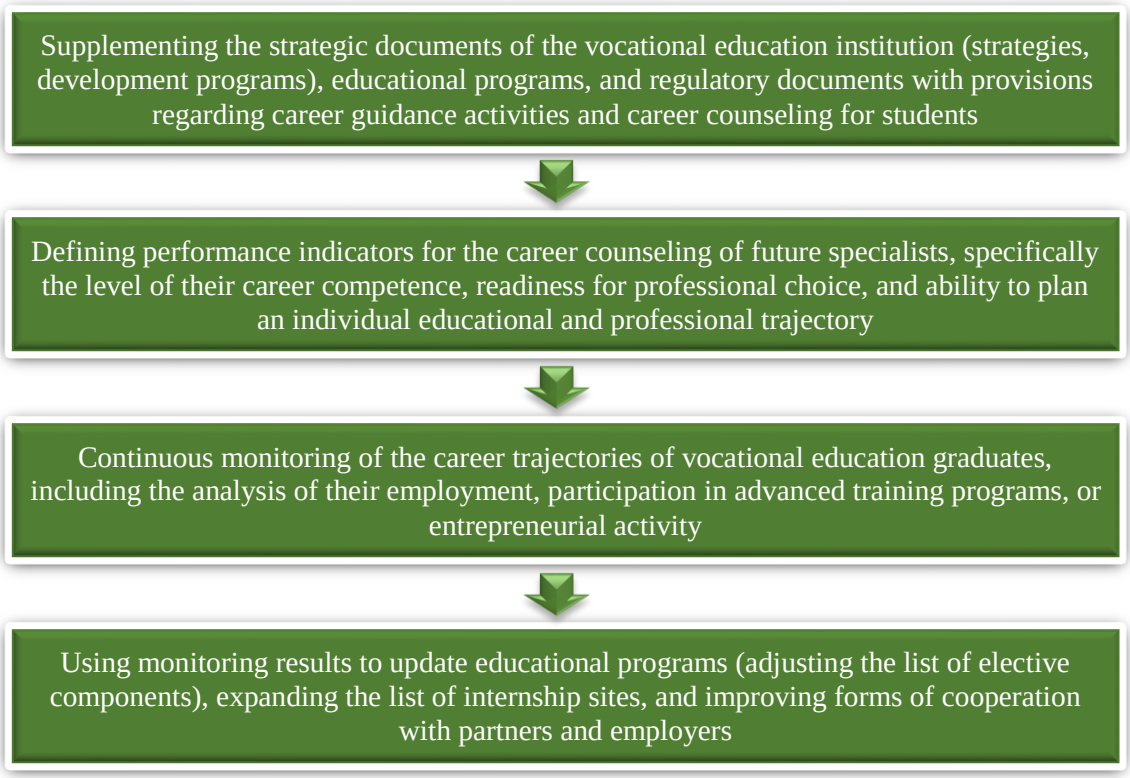
According to domestic legislation, the education quality assurance system requires procedures for monitoring, evaluation, and improvement of educational processes. In particular, the Law of Ukraine “On Vocational Education” outlines key mechanisms for organizing and controlling the quality of professional training, establishes requirements for educational standards and the assessment of learners’ acquired competencies, and mandates the implementation of internal and external quality assurance systems in vocational education institutions. The provisions of this law highlight the necessity of applying an integrated approach to monitoring educational outcomes, which entails systematic evaluation of the effectiveness of educational programs, teaching methods, instructors’ qualifications, and learners’ satisfaction, taking into account the best European practices in vocational education and training (Verkhovna Rada of Ukraine, 2025c). Accordingly, the internal quality assurance system of vocational education should be oriented toward the continuous improvement of the content and technologies for training future specialists in line with labor market needs.

Within the vocational education system, key integrative indicators of training quality are considered to be graduates’ employment rates in their trained profession and the alignment of acquired competencies with employers’ qualification requirements. Employment, in this context, is rightly viewed not only as a statistical indicator but also as a measure of the effectiveness of program implementation and of career guidance and counseling support. In contrast to national approaches, European approaches to quality in

VET (Cedefop, 2020) include additional indicators, namely: employment rates of graduates over a defined period after graduation; the alignment of performed work with acquired qualifications; employer satisfaction with graduates' professional preparation; the proportion of learners involved in internships, industrial practices, and dual learning forms; and the level of continuation of education or professional upskilling.

Given the above, the integration of career guidance and counseling into the internal quality assurance system of vocational education is feasible through the implementation of its key mechanisms, which are visually represented in Figure 5.1.

Figure 5.1. Mechanisms for Integrating Career Guidance and Counseling into the Internal Quality Assurance System of Vocational Education



Thus, career guidance and counseling are transforming from an auxiliary activity into a structural component of the internal quality assurance system (IQAS) and are understood as a significant determinant of the quality of the educational process, directly influencing graduate competitiveness and the reputation of vocational education institutions.

At the current stage of harmonizing the Ukrainian vocational education system with European standards, principles of lifelong guidance, graduate tracking, and skills forecasting are being adapted to the conditions of the national labor market. In European educational policy, the concept of "lifelong guidance" is considered a systemic mechanism for supporting individuals in making educational and career decisions throughout their lives, integrating informational, advisory, and analytical tools into the education system and labor market (Cedefop, 2020, p. 18). One important tool for ensuring that vocational training aligns with economic needs is graduate tracking systems, which allow for the analysis of employment outcomes, professional mobility, and the alignment of acquired qualifications with actual labor market demands (European Commission, 2020, p. 6). In European countries, these tools are closely linked with skills forecasting systems, which are based on analyses of economic trends, technological changes, and demographic dynamics. Such forecasting models make it possible to anticipate future qualification needs and adjust educational policies according to expected changes in employment structures (Cedefop, 2018, pp. 14–16). European research indicates that systematic use of skills forecasting tools facilitates more effective alignment of vocational education content with economic needs and enhances the adaptability of educational systems to structural labor market changes (Cedefop, 2021, pp. 9–11).

At the same time, the national specificity of career guidance and counseling in Ukraine is largely determined by contemporary socio-economic transformations and wartime challenges. This primarily refers to the impact of war-related factors on the labor market structure, manifested in changes to sectoral employment composition, increased demand for technical and skilled trades, and the growing role of professional mobility. Large-scale internal migration, enterprise relocation, and regional economic transformations have resulted in significant territorial differentiation of qualification demand, requiring flexible mechanisms of career guidance and counseling that take regional labor market characteristics into account. Moreover, a strategic task for Ukraine's vocational education system is the preparation of qualified personnel for post-war reconstruction in infrastructure, energy, transport, construction, and industry.

Under these conditions, career guidance and counseling acquire not only an informational but also a strategic function, as they are aimed at fostering informed professional choices among young people while considering the country's economic development prospects and anticipated qualification needs. As Ukrainian researchers note, integrating career guidance activities into the internal quality assurance system of

vocational education contributes to the increased relevance of educational programs and strengthens the linkage between education and the labor market (Radkevych, 2024, pp. 2–3; Bazyl, 2025, p. 373).

Thus, the theoretical and methodological model of career guidance and counseling within the internal quality assurance system of vocational education, taking into account the national context, should integrate: systemicity and cyclicality (in accordance with the EQAVET framework); a competency-based orientation; evidence-based decision-making; and a results-oriented focus on graduate employment and professional mobility.

The theoretical and methodological foundation for designing such a model is formed by the previously outlined systemic, activity-based, learner-centered, competency-based, axiological, and evidence-based approaches, which provide a holistic understanding of the process of individual professional self-determination in connection with the educational environment and the socio-economic needs of society. In developing the model, European approaches to career guidance system development were considered, including the concepts of lifelong guidance, graduate tracking, and skills forecasting, along with the national specificities of Ukraine's vocational education system (Radkevych, 2024, pp. 2–5). This approach allows for the integration of strategic priorities of European educational policy with contemporary socio-economic challenges faced by Ukrainian society.

Structurally, the model of career guidance and counseling within the internal quality assurance system of vocational education should include the following interrelated components: target, content, organizational-process, diagnostic-monitoring, and outcome.

The target component of the model defines the strategic aim of career guidance activities, which is to develop learners' readiness for informed professional choices, the construction of individual career trajectories, and adaptation to the dynamic conditions of the modern labor market. Achieving this aim requires addressing a set of tasks related to developing students' career competence, professional planning skills, self-awareness, and reflection.

The content component encompasses a system of career guidance activities, informational and advisory services, educational modules, and practice-oriented forms of engagement aimed at shaping learners' understanding of the world of professions, labor market requirements, and prospects for professional development. Career centers within vocational education institutions play a key role in implementing this component,

organizing individual and group career counseling, conducting professional diagnostics, and fostering partnership interactions with employers.

The organizational-process component involves creating appropriate organizational and pedagogical conditions for implementing career guidance activities within the internal quality assurance structure. These conditions include integrating career counseling into the institution's strategic documents, developing internal procedures for monitoring the effectiveness of career guidance work, and fostering cross-sector partnerships among educational institutions, employers, employment services, and public organizations.

The diagnostic-monitoring component of the model ensures the systematic evaluation of the effectiveness of career guidance activities and their impact on learners' educational outcomes. It involves the use of tools for diagnosing students' professional interests and abilities, analyzing graduate employment indicators, monitoring their career trajectories, and assessing employer satisfaction with the level of graduates' professional preparation.

The outcome component reflects the expected results of the model's implementation, manifested in an increased level of professional self-determination among learners, enhanced readiness for career development, and improved graduate employment rates in their trained professions. Simultaneously, the implementation of the model contributes to improving the quality of educational programs and strengthening the connection between the vocational education system and the labor market.

An important aspect of developing the model is taking into account the national context of Ukraine's vocational education system, which is shaped by contemporary socio-economic transformations driven by European integration processes, structural changes in the economy, and wartime challenges. Under these conditions, career guidance and counseling should contribute to the formation of a skilled workforce for the post-war reconstruction of the country, as well as the development of infrastructure, industry, and the technology sector.

Thus, the proposed methodological foundations for career guidance and counseling within the internal quality assurance system of vocational education reflect the integration of European educational approaches with national economic and social development needs, ensuring their practical orientation and applicability within the activities of vocational education institutions.

5.3. PROFESSIONAL ORIENTATION AND CAREER COUNSELLING AS COMPONENTS OF IMPROVING THE QUALITY OF VOCATIONAL AND PROFESSIONAL PRE-HIGHER EDUCATION

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The section presents a comprehensive theoretical, methodological, and empirical analysis of professional orientation and career counseling as key instruments for enhancing the quality of vocational education amid socio-economic transformation, digitalization, and rapid labor market changes. Their strategic role in developing professional self-awareness, career competence, learner agency, and readiness to construct an individual career trajectory is substantiated. Professional orientation and career counseling are conceptualized as an integrated system of psychological and pedagogical support for professional development. The evolution of scholarly approaches, their interdisciplinary character, and their significance for graduate competitiveness and institutional effectiveness are examined. The study defines their place within the internal quality assurance system and justifies their systematic integration into the educational process. Empirical findings reveal the levels of professional orientation, career aspirations, and motivational determinants of career choice among higher education students. The effectiveness of the developed career counseling program is confirmed by statistically significant improvements in informed career choice, motivation for professional self-development, and career planning skills. A structural model for integrating career guidance into vocational education quality assurance is proposed, with practical implications for educational institutions and career support services.

Keywords: *professional orientation; career counseling; quality assurance in education; vocational education; career competence; professional self-awareness; career planning*

In the context of dynamic socio-economic transformations, the digitalization of the economy, changes in the content of professional activity, and the growing demands of the labor market, the issue of improving the quality of vocational and professional pre-tertiary education is becoming increasingly significant. One of the key factors in ensuring this quality is career guidance and career counseling, which contribute to the formation of informed career choices, the development of career competence, and learners' readiness to construct an individual professional trajectory (Savickas, 2013, pp. 147–153; Brown & Lent, 2020, pp. 129–163; Guichard, 2013, pp. 7–9).

Career guidance and career counseling are increasingly viewed not as episodic informational activities, but as a holistic system of psychological and pedagogical support

aimed at developing subjectivity, autonomy, and personal responsibility for one's professional future.

In contemporary scholarly discourse, career guidance is interpreted as a continuous process of professional self-determination and self-realization that encompasses all stages of an individual's life and professional pathway. It integrates psychological, pedagogical, social, and economic dimensions, thereby forming the foundation for the development of an individual's career competence (Super, 1980, pp. 283–296; Brown & Lent, 2020, pp. 201–235).

Career guidance is a purposeful process of preparing an individual for a conscious choice of profession, taking into account their individual abilities, interests, and aptitudes, as well as the needs of society and the labor market. In classical approaches, it was primarily associated with providing information about the world of professions, vocational diagnostics, and counseling support (Holland, 1997; Sampson et al., 2023).

We also consider career guidance as an integrated system of psychological-pedagogical, socio-economic, and organizational-methodological measures aimed at assisting an individual in exploring the world of professions, assessing their own interests, abilities, values, and opportunities, and making an optimal career decision. Such a system encompasses a set of interrelated components: career information, counseling, diagnostics, selection, adaptation, and support.

From the perspective of the competency-based approach, career guidance is aimed not only at choosing a profession, but also at developing the ability to analyze one's own resources, align them with the requirements of professional activity, design an individual career development trajectory, and adjust it throughout life (Akkermans et al., 2013, pp. 246–247; Hirschi, 2018).

Thus, career guidance appears as a multidimensional process focused on fostering an individual's readiness for responsible career choice, adaptation to changing working conditions, and active management of their own career.

In contemporary research, career counseling is viewed as a form of psychological and pedagogical support for individuals in the process of professional and career development. Unlike traditional vocational counseling, it is oriented not only toward assisting with career choice, but also toward supporting the construction of a career trajectory throughout the lifespan (Savickas & Porfeli, 2012, pp. 662–665; McMahon & Patton, 2017, p. 270).

The essence of career counseling lies in creating conditions for individuals to become aware of their own values, motivational orientations, life and professional goals, as well as in developing their capacity to make responsible decisions regarding their professional future.

Modern approaches to career counseling are based on the principles of individualization, subjectivity, partnership-based interaction, reflexivity, and continuity. Particular importance is given to narrative, coaching, competency-based, and constructivist models of counseling, which promote active engagement of individuals in planning and managing their own careers (McCash et al., 2021, pp. 2–11; Hooley et al., 2011, pp. 6–7).

Career counseling performs a number of important functions: diagnostic, motivational, developmental, prognostic, and corrective. Through these functions, it ensures the development of career adaptability, professional mobility, and psychological readiness for change (Rudolph et al., 2017; Savickas & Porfeli, 2012, pp. 661–669).

Career counseling goes beyond the initial choice of profession and involves long-term support of the individual in the process of professional formation, development, and self-realization. Its essence lies in fostering the ability to consciously design a career, make responsible decisions, develop skills for managing one's own career trajectory, and enhance professional mobility and adaptability.

Modern concepts view a career as a multidimensional process of personal self-realization that integrates professional, social, educational, and personal achievements. In this context, career guidance and career counseling gain strategic importance as tools for ensuring graduates' competitiveness and the sustainable development of the education system.

To define its essence, a theoretical analysis of career guidance and career counseling was conducted in the context of contemporary socio-economic transformations. The evolution of scientific approaches to understanding the content and functions of career guidance was revealed, and its interdisciplinary nature was outlined. Major concepts of career counseling were analyzed, and their role in ensuring professional self-determination, adaptability, and individual competitiveness in the labor market was determined. The feasibility of integrating career guidance and career counseling into a comprehensive system of pedagogical support for the development of career competence was substantiated.

Socio-economic changes, digitalization, globalization processes, and the dynamic development of the labor market necessitate a reevaluation of traditional approaches to career guidance and counseling. Under these conditions, the formation of an individual's ability to make conscious career choices, flexibly construct an individual career trajectory, and be ready for continuous professional development and self-realization becomes especially relevant.

In contemporary conditions, career guidance and career counseling are increasingly viewed as interrelated components of a unified system of pedagogical support for professional formation.

Such integration ensures a holistic influence on the process of professional self-determination; the alignment of diagnostic, informational, developmental, and counseling activities; and continuous career support at different stages of education and professional activity.

Within the integrated approach, career guidance primarily performs a preventive and informational-developmental function, while career counseling focuses on individualized support for career planning and the implementation of professional plans. This allows individuals to develop a stable motivation for professional self-development, responsibility for their own career, and the ability for effective self-realization.

In contemporary socio-economic conditions, the vocational education system plays a key role in forming competitive human capital capable of acting effectively in the context of dynamic labor market changes, technological transformations, and socio-cultural challenges. Ensuring the quality of vocational education is seen as a multidimensional process aimed at aligning educational outcomes with the expectations of learners, employers, society, and the state.

The quality of vocational education is determined not only by the level of professional competencies acquired, but also by the degree of personal potential development, students' readiness for self-realization, professional mobility, and lifelong learning (UNESCO, 2016; OECD, 2019, p. 9). In this context, career guidance and career counseling gain particular significance as integrated components of the internal quality assurance system. Career guidance and counseling are regarded as strategic tools for managing the quality of the educational process, contributing to increased effectiveness, relevance, and social impact (Harvey & Green, 1993, pp. 10–28; Watts, 2014).

Vocational education is largely defined by the alignment of learning outcomes with labor market needs, learners' expectations, and societal demands. In this regard, career guidance and career counseling serve as important mechanisms for harmonizing the interests of individuals, employers, and educational institutions. On one hand, career guidance contributes to increased motivation for learning, conscious choice of a specialty, and a reduction in the risk of professional maladjustment and student dropout. On the other hand, career counseling ensures the development of a stable professional identity, the enhancement of metacognitive skills in planning, self-reflection, decision-making, and self-regulation, which are key indicators of the quality of specialist training.

The modern model of ensuring the quality of vocational education is based on the principles of student-centeredness, practice-oriented learning, partnerships with employers, inclusivity, and openness (European Association for Quality Assurance in Higher Education et al., 2015, p. 6). It involves systematic assessment of educational outcomes, monitoring graduates' career trajectories, and developing mechanisms to support learners' professional self-determination and career development. Within this

framework, career guidance and career counseling are considered not as auxiliary services but as strategic tools for managing the quality of the educational process, contributing to enhanced effectiveness, relevance, and social impact.

Integrating career guidance and career counseling into the educational process involves establishing a system of early career orientation, implementing career-oriented educational programs, fostering partnerships with employers, and creating career development centers, which international research has shown to be an effective practice for ensuring education quality (Hooley et al., 2011, pp. 5–7; McCash et al., 2021, pp. 5–17). Such measures support the formation of flexible educational trajectories, individualized learning, and increased adaptability of graduates to changing professional environments.

Within the structure of the internal quality assurance system, career guidance performs a number of key functions:

- diagnostic – identifying students' individual inclinations, abilities, professional interests, and career expectations;
- prognostic – determining potential educational and professional development trajectories;
- motivational – fostering a positive attitude toward the chosen specialty and professional activity;
- corrective – timely adjustment of professional plans according to changes in personal priorities and labor market conditions;
- informational – providing access to up-to-date data on professions, qualification requirements, and employment opportunities.

Integrating career guidance activities into the quality assurance system contributes to reducing academic maladjustment and student dropout rates, increasing motivation for learning, enhancing satisfaction with the educational process, and fostering professional identity and readiness for employment.

Thus, career guidance serves as an important mechanism for enhancing the quality of educational outcomes and the social effectiveness of vocational education institutions.

Career counseling is a system of psychological, pedagogical, and informational support for individuals in the process of professional self-determination, career trajectory planning, and adaptation to the labor market. In the context of ensuring the quality of vocational education, it is regarded as a strategic resource for developing competitive next-generation professionals.

The primary goal of career counseling is to enable learners to apply the key competencies acquired during their studies: professional knowledge, skills, and abilities; the development of reflective and self-awareness capacities; the ability to make professionally significant decisions; readiness for professional mobility; skills in

designing an individual career trajectory; as well as self-presentation and effective communication with employers.

Career counseling is delivered through individual and group formats, including consultations, coaching sessions, training workshops, masterclasses, career navigation tools, internships, dual education programs, and mentorship projects. A critical condition for its effectiveness is integration with the educational process and close collaboration with social partners.

Within the framework of the education quality assurance system, career counseling performs the following functions:

- analytical – monitoring students' career needs and professional expectations;
- design – supporting the development of individual career plans;
- adaptive – preparing students for entry into the professional environment;
- evaluative – tracking the effectiveness of educational programs through analysis of graduates' employment outcomes.

The effectiveness of career counseling directly impacts the institution's image, its level of competitiveness, and indicators of social responsibility.

Effective quality assurance in education requires the creation of an integrated model of career guidance and career counseling, combining diagnostic, educational, counseling, and practical components.

Structurally, such a model includes (Figure 5.2):

1. Target component – the development of professional identity and readiness for career self-realization.

2. Content component – a system of knowledge about the professional world, career strategies, and the labor market.

3. Process component – a set of methods, forms, and technologies for career guidance and counseling activities.

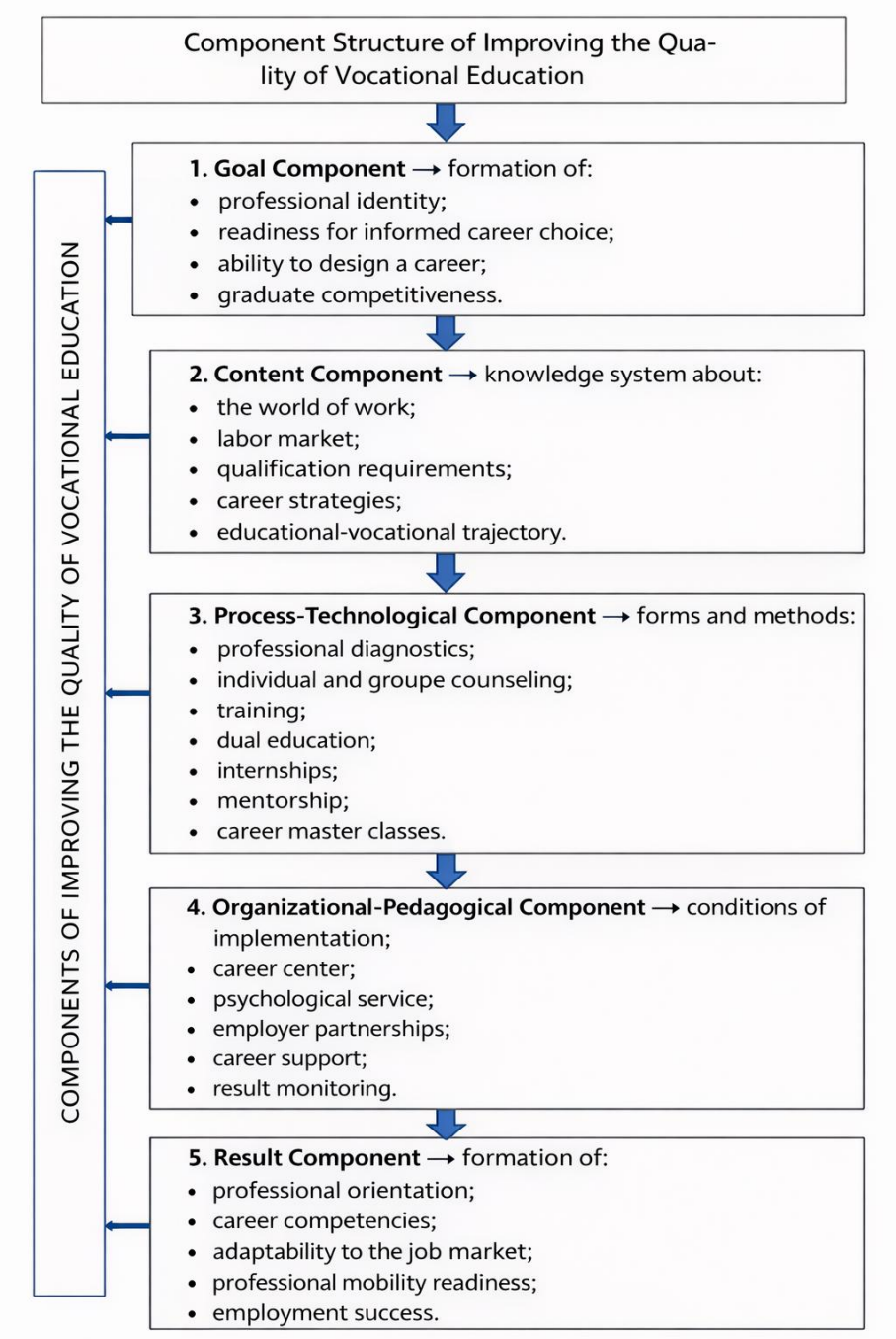
4. Outcome component – the formation of professional orientation, career competencies, and readiness for employment.

The functioning of this model assumes close interaction among the institution's administration, teaching staff, psychological services, career centers, employers, and the learners themselves.

The structural-logical model of career guidance and career counseling within the system of vocational education quality assurance reflects the integration of target, content, process-technological, organizational-pedagogical, and outcome components, the interaction of which ensures the development of professional identity, career competencies, and learners' readiness for successful professional self-realization.

This model, representing the integration of career guidance and career counseling into the education quality assurance system, allows the creation of a coherent educational and career space in which the harmonious development of the individual and the formation of their professional potential take place.

Figure 5.2. Structural-logical model of vocational guidance and career counselling



Career guidance and career counseling contain significant pedagogical potential, manifested in the development of learners' personal, social, and professional competencies. They contribute to the formation of professional self-awareness, adequate self-assessment and aspiration levels, motivation for professional self-development, a

value-based attitude toward work, and skills in critical thinking and reflection (Bandura, 1997; Ryan & Deci, 2017; Brown & Lent, 2020, pp. 1–29).

Professional self-awareness is considered an integrative psychological construct reflecting an individual's system of representations about themselves as a subject of professional activity, including awareness of personal abilities, interests, and values; understanding the requirements of the profession; evaluating one's level of professional competence; constructing professional identity; and forming career intentions and goals (Super, 1980, pp. 285–288; Savickas, 2013, pp. 152–180).

The content of professional self-awareness development in the context of career counseling and vocational education quality assurance has a component-based structure, which includes: acquiring and applying knowledge about the profession, labor market requirements, and personal abilities (*cognitive and operational-activity component*); self-assessment of professional suitability and one's perception of oneself as a professional (*emotional-evaluative component*); professional interests, motives, needs, and career goals (*motivational component*); and awareness of personal strengths and weaknesses, self-control, self-development, planning, and adjustment of the career trajectory (*reflective-regulative component*) (see Figure 5.3).

Figure 5.3. Structural and functional model of career competence of students

Career counseling acts as a system-forming factor in the development of professional self-awareness, providing a diagnostic function (identifying interests, abilities, values, analyzing professional inclinations, diagnosing career orientations); a reflective-developmental function (developing self-awareness skills, enhancing reflection, understanding life and professional experience); an informational-educational function (familiarizing learners with the professional world, analyzing labor market trends, forming accurate professional perceptions); and a design function (constructing an individual career trajectory, setting realistic goals, planning professional development) (McMahon & Patton, 2017, pp. 270–272; Guichard, 2013, pp. 7–11).

The effectiveness of counseling activities is ensured by mechanisms for developing professional self-awareness, including self-knowledge, reflection, internalization of professional values, professional identification, narrative reconstruction of life experiences, and goal-setting. Mastery of these mechanisms, and the ability to activate them in the learner's consciousness, characterize the pedagogical skill of the career guidance and counseling specialist and ensure the quality of career competence development in learners.

A particularly important role in enhancing the quality of vocational education is played by the development of learners' career competence – their ability to analyze their own potential, define professional development goals, plan the steps to achieve them, manage resources, and evaluate the results of their activities. Developing this competence increases graduates' readiness for lifelong learning and professional mobility.

Pedagogical support for career guidance and counseling is implemented through the use of interactive learning technologies, training methods, project-based activities, portfolios, case studies, coaching, and mentoring practices, which ensure an active role for learners in the process of their professional development.

The enhancement of vocational education quality is supported by technologies and methods for developing professional self-awareness, which differ in their objectives, content, and pedagogical potential. Specifically, the goal of diagnostic methods is to describe professional interests using questionnaires; testing determines the content of career orientations, while methods for studying professional identity – such as assessing readiness for career choice, identifying the stage of professional self-determination, and selecting differentiated educational strategies – reveal the pedagogical potential of career guidance and counseling. Reflective technologies, including coaching questions, reflective interviews, and career journals; project-based methods, such as life-line

mapping, career map development, individual career planning, and scenario-based forecasting of professional development; as well as narrative methods, including career stories, autobiographical narrative techniques, and professional case analysis, enable the construction of individualized career support trajectories (Hooley et al., 2011, p. 6; McCash et al., 2021, pp. 3–12).

The outcome of developed professional self-awareness includes: conscious career choice, stable professional motivation, adequate self-assessment, and flexibility in career behavior. The latter is manifested in readiness for change and professional mobility and potentially ensures competitiveness in the labor market (Akkermans et al., 2013, pp. 255–260; Fugate et al., 2004).

Thus, the development of professional self-awareness through career counseling is a complex, multi-level, and dynamic process that facilitates the formation of the individual as an active agent of professional and life self-determination. Career counseling creates conditions for developing reflection, awareness of professional resources, constructing an individual career strategy, and forming professional identity, which together enhance the effectiveness of professional self-realization and personal adaptability in the context of the contemporary labor market.

The next component of the pedagogical potential of career guidance and counseling is self-assessment and aspiration level, which serve as fundamental psychological regulators of professional self-determination, as they determine: perception of one's own abilities; expectations regarding professional success; the choice of the complexity of professional goals; and readiness to overcome difficulties.

In the pedagogical dimension, these factors act as key mechanisms for developing an individual's agency in the process of career guidance and counseling.

The pedagogical potential of adequate self-assessment and optimal aspiration level lies in their ability to: ensure realistic professional self-determination, activate internal motivation, and foster readiness for professional development and the construction of an individual career trajectory. The main pedagogical effects in career guidance and counseling involve the implementation of functions related to the realism of professional choice, such as adequate self-assessment (which helps align "want – can – need"; reduces the risk of professional illusions and accidental choices; and strengthens the persistence of professional intentions).

As a result, vocational learners form well-grounded professional decisions regarding career orientation and trajectory choice. The motivational sphere is regulated,

an optimal level of achievement motivation is established, and the level of educational and professional activity increases. Consequently, the development of intrinsic educational and professional motivation is actualized.

The pedagogical potential of career guidance and counseling is embedded in the development of agency and responsibility, as well as in stimulating self-development and self-improvement. Adequate self-assessment plays a particularly important role, as it ensures responsibility for personal choices, forms an agentic stance in career building, and develops career autonomy. The activation of this potential ensures the emergence of an active agent in their professional path. Discrepancies between self-assessment and aspiration levels can lead to frustration, professional burnout, and disappointment in the chosen profession.

Pedagogy can provide an adequate balance, reducing the risk of professional crises and enhancing resilience and adaptability. The outcome is the development of professional resilience, characterized by psychological stability, the ability of future professionals to effectively cope with stress, challenging life circumstances, and traumatic events, adapt to new conditions, and recover (return to normal) after crises without breaking down, while maintaining mental health.

The realization of the pedagogical potential of career guidance and counseling is carried out through the design of an individual career trajectory. In this process, adequate self-assessment and optimal aspiration levels play a crucial role, as they allow for realistic career planning, support step-by-step professional growth, and develop career self-management skills. As a result, individuals acquire the ability to independently design their own career paths.

Thus, the pedagogical potential of career guidance and counseling is manifested in ensuring realistic professional self-determination, fostering intrinsic motivation for educational and professional activities, developing the individual's agentic position, and designing an individual career trajectory. Collectively, these processes contribute to sustainable professional development and the prevention of career-related crises.

5.4. THE ROLE OF THE PROFESSIONAL CULTURE OF PRACTICAL PSYCHOLOGISTS IN ENSURING THE QUALITY OF THE EDUCATIONAL ENVIRONMENT IN EDUCATIONAL INSTITUTIONS

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The professional culture of practical psychologists is theoretically substantiated as a strategic factor in ensuring the quality of the educational environment in educational institutions in the current conditions of Ukrainian society. The principles of psychological safety in the educational environment are defined; criteria reflecting the structure and level of development of the professional culture of practical psychologists are identified. The development of the professional culture of a practical psychologist is considered as a dialectical process characterized by reproductive, constructive, and creative levels of development. The professional culture of a practical psychologist is a factor in the harmonious interaction of participants in the educational process at all levels of the educational space.

Keywords: *professional culture, development of professional culture, practical psychologists, participants in the educational process, quality of the educational environment, educational institutions*

At the current stage of development of Ukrainian society, the educational space is undergoing radical transformations caused by the synergistic influence of globalization processes, institutional modernization, and unprecedented challenges caused by prolonged military aggression. As we have noted in previous scientific studies, coordinated interaction between social institutions is extremely important for the successful socialization of students in a complex socio-economic situation (Lapa, 2016).

In this context, the issue of the quality of the educational environment goes beyond the scope of scientific research in educational sciences and management, acquiring the status of a fundamental condition for national security and the preservation of human capital. However, despite the existence of a regulatory framework governing the parameters of educational quality, in the actual practice of educational institutions, there is a certain methodological discrepancy between formal indicators of success and the mental well-being of participants in the educational process.

The relevance of our research is reinforced by the fact that, in conditions of chronic stress and social turbulence in Ukrainian society, traditional mechanisms of pedagogical influence are proving insufficient to maintain the stability (resilience) of the

educational ecosystem. As Panok (2022) notes, the strategic development of psychological services until 2030 should be aimed at transitioning from a model of responding to specific requests to a model of designing a safe and developmental environment. This requires practical psychologists in educational institutions not only to clearly perform their job duties, but also to have a high level of professional culture, which acts as an internal integrator of their ethical attitudes, methodological reflection, and ability to engage in creative activity.

Contemporary scientific research on the definition of "professional culture" allows us to consider it as a higher level of professionalism, where a specialist becomes not only a performer of professional duties, but also an active agent of change, capable of transforming the organizational culture of an educational institution. According to the World Health Organization (2022, pp. 51–65), there is a global increase in psycho-emotional disorders among young people. This fact requires educational institutions to have the characteristics of therapeutic environments, where psychological safety is a core value. This is confirmed by Amy Edmondson's research on psychological safety as a prerequisite for learning and innovation. Therefore, it is a psychologist with a high level of professional culture who is capable of acting as a moderator of trust and open dialogue in the educational environment (Edmondson, 2018, pp. 1–8).

At the same time, an analysis of contemporary scientific literature reveals a contradiction between society's high demands on the personality of a practical psychologist as a guarantor of the psychological comfort of participants in the educational process and the insufficient theoretical development of mechanisms for influencing the qualitative parameters of the educational environment through their professional culture. The need to overcome this contradiction, as well as the need to develop new effective models for shaping the professional culture of psychological service specialists in a crisis-ridden society, determined the choice of the topic and purpose of our study.

The objective need to highlight the cultural and psychological factors of education quality also correlates with the guidelines of the OECD Learning Compass 2030, which emphasizes that the educational environment should function as an ecosystem that supports not only cognitive development but also the social and emotional well-being of all its participants (OECD, 2019, pp. 1–12). Thus, the professional culture of a practical psychologist emerges as a semantic core that concentrates all levels of the educational space: from individual interaction with participants in the educational process to the formation of the general policy of security and trust of a particular institution.

The purpose of our study is to theoretically substantiate and conceptualize the role of the professional culture of practical psychologists as a strategic factor in ensuring the

quality of the educational environment of educational institutions in the context of modern social transformations.

It should be noted that analyzing the problem of the quality of the educational environment in modern scientific coordinates requires abandoning a narrowly functional approach in favor of multidimensional conceptualization that integrates philosophical, psychological, and sociocultural dimensions. In the context of the systematic modernization of domestic education, methodological reflection has made it possible to identify the professional culture of the practical psychologist as a system-forming factor that determines the vector of development of an educational institution.

The fundamental basis for the development of modern education is the human-centered paradigm. According to the views of Kremen, Lyashenko, and Lokshina (2020), modern education should be transformed into a space for the formation of subjectivity, where the main value is not the amount of knowledge acquired, but the ability of the individual to self-actualize and identify culturally in a global world. In this context, the quality of the educational environment is assessed by the degree of its "human dimension", that is, its ability to provide conditions for the realization of each individual's potential. This fact places a special mission on the practical psychologist – to be the guarantor of adherence to the human-centered paradigm in practice.

The axiological approach finds its logical continuation in Bekh's concept of personality-oriented education. The author emphasizes that any educational influence is effective only when it is based on value-semantic interaction (Bekh, 2021). Thus, the professional culture of a psychologist is an expression of "higher meanings", and the ethical position of a specialist is a benchmark for shaping the moral and psychological climate of the entire team. As the above-mentioned scientist notes, the educational environment is, first and foremost, a space of trust and responsibility that cannot be created by administrative methods alone.

For a comprehensive understanding of the modern educational environment of an institution, an ecosystem approach is important, which is considered in current OECD documents (2019, pp. 5–12) as a key mechanism for sustainable development of education. The educational environment is interpreted as a complex, multi-level ecosystem where each element is in a state of constant interdependence. According to Guy-Evans' modern interpretation of Bronfenbrenner's works, the professional culture of a psychologist in this system acts as a mediator between its different levels, namely between:

- the microsystem, where direct interaction between the psychologist and the student takes place, supporting individual development trajectories;

- the mesosystem: the space for harmonizing relationships between the family, educational institution, teaching staff, and administration;
- the ecosystem and macrosystem, where professional values are transmitted to a broader social context and community educational policy is formed (Guy-Evans, 2024).

Based on the above systemic vision, we can argue that the quality of the educational environment is an emergent property that arises only when the professional culture of the psychologist is highly integrated into all links of the educational process of the institution.

Of particular importance for our study is the subject-activity approach, methodologically substantiated in the works of Maksymenko (2024). The scientist proves that the professional development of a psychologist is a process of continuous self-realization and self-projection. Based on this, professional culture is not a static set of knowledge, but a living "genetic unit" of professionalism. This feature allows the specialist not only to adapt to the environment, but also to actively transform it. The psychologist emerges as a subject of culture creation, whose activity is aimed at overcoming destructive tendencies in the educational institution, and also allows building a vector of development based on humanistic ideals.

In the modern scientific paradigm, the quality of the educational environment is considered not as a mechanical set of material, technical, or instructional and methodological parameters, but as a complex integral characteristic of interaction that determines the trajectory of personal development of all its subjects. Research by Karamushka and Dektyaryova (2013, pp. 203–210) allows us to determine the quality of the environment through the prism of its organizational culture, where the key indicators are the level of solidarity of the team, common values, and the effectiveness of psychological support for innovative changes.

In our opinion, the quality of the educational environment is an emergent property. As noted by contemporary Ukrainian researchers, the psychological quality of the environment is determined by its ability to satisfy the needs of participants for security, recognition, and trusting communication, which, in turn, is a necessary condition for maintaining mental health and preventing destructive behavior (Baidyk, et al., 2024).

Thus, the professional culture of a practical psychologist is the highest form of manifestation of his professionalism, integrating cognitive, axiological, and praxeological components into a coherent system. According to Panok (2013), unlike purely functional competence, professional culture encompasses not only professional knowledge, but also personal maturity, ethical responsibility, and professional identity, which is formed in the process of long-term professional development.

Within the framework of our study, based on the analysis of Ukrainian researchers' works on the personal development of specialists, we distinguish the following structural levels of professional culture of a practical psychologist, which are in a state of constant interaction: worldview-diagnostic, intellectual-reflective, technological-communicative.

The worldview-value level can be called the axiological foundation. This level of professional culture is system-forming, as it determines the internal position of a practical psychologist and their ethical orientation. It involves a deep internalization of humanistic values, the specialist's awareness of their professional mission as a factor in the social protection of the individual, and a willingness to unconditionally accept their subjectivity. It is at this level that the ethical imperative is formed, which is an internal regulator of the specialist's behavior in complex ethical conflicts of the educational process, ensuring the transition from the formal performance of duties to conscious service to the values of health and development.

The technological and communicative level determines the methodological culture, representing the practical psychologist's ability to analytically interpret the educational situation and construct original models of psychological support. As N. Chepeleva emphasizes, professional culture is impossible without developed self-reflection, which allows the specialist to go beyond standard diagnostic schemes and carry out a systematic analysis of the psychological causes of educational problems (Chepelieva, 2018). This level requires systematic professional thinking, mastery of evidence-based practices, and the ability to supervise professional activities, which is the basis for taking informed actions by the institution's psychological service.

The technological and communicative level represents the praxeological culture of a specialist. It is an external manifestation of professional culture, reflecting the skill of professional dialogue, facilitation, and the ability to constructively resolve conflicts in the multi-subject environment of an educational institution. According to research by Karamushka and Lolenko (2025), the communicative competence of a psychologist is a key resource for maintaining the psychological health of teachers and creating an atmosphere of trust. At this level, the technological skills of a specialist are implemented: the application of methods of diagnosis, correction, prevention, development, and mediation, which directly influence the formation of the qualitative parameters of the educational environment.

The modern reality of our research is the recognition of psychological safety as a fundamental principle and, at the same time, as a key result of the implementation of the professional culture of a practical psychologist. According to the National Strategy for the Development of a Safe and Healthy Educational Environment, safety is considered a multidimensional construct that includes physical protection, information hygiene, and

psychological comfort (Verkhovna Rada of Ukraine, 2020c). We argue that a practical psychologist with a high level of professional culture implements the principle of psychological safety not as a passive observer, but as an active agent of influence on the system, acting in the direction of three synergistic vectors.

The diagnostic and prognostic vector is aimed at early detection of latent threats to the socio-psychological climate of the educational institution and the implementation of appropriate preventive measures. The preventive culture of a practical psychologist manifests itself through regular monitoring of the level of safety, sociometric studies to identify cases of bullying or mobbing, as well as analysis of the dynamics of the emotional state of the team. Also, based on the research of Karamushka and Dektyareva (2013, pp. 203–210), the prognostic function of a psychologist is the ability to predict the destructive consequences of management decisions for psychological comfort. Based on the data obtained, the psychologist forms a forecast of the situation's development and develops preventive strategies to avoid negative phenomena.

The corrective-developmental vector is aimed at forming self-regulation, emotional stability, and non-violent communication skills in participants in the educational process. This involves the implementation of training programs aimed at developing emotional intelligence, mastering stress management techniques, and developing mediation skills. According to the World Health Organization (2022, pp. 248–250), it is the development of psychological resilience that is a key tool for ensuring safety in conditions of chronic stress.

The organizational and cultural vector involves initiating and supporting changes in the norms, rules, and values of educational institutions aimed at promoting inclusion, openness, and mutual respect. The psychologist acts as a facilitator for the adoption of new organizational norms that regulate safe interaction. This correlates with Edmondson's concept of psychological safety as a prerequisite for learning and innovation (Edmondson, 2018, pp. 1–8), where the psychologist structures the space to minimize interpersonal risks.

In a crisis-ridden society, practical psychologists play a particularly important role in providing optimal psychological support to teaching staff. A creative level of professional culture development allows practical psychologists to supervise teachers, helping them to prevent secondary traumatization and emotional exhaustion. Psychological support for teaching staff is a critical condition for maintaining the overall quality of the educational environment. This support is provided through the creation of support groups, the conduct of Balint groups, and the training of teachers in professional self-hygiene techniques (Bondarchuk, 2021).

Within the framework of our concept, aimed at theoretically substantiating the role of the professional culture of a practical psychologist in improving the quality of the educational environment, we have proposed a comprehensive criteria-based diagnostic tool. This apparatus is based on the identification of four fundamental, interrelated criteria, which together reflect the structure and level of development of a specialist's professional culture: value-semantic (axiological dominant), cognitive-methodological (intellectual dominant), communicative-interactive (interaction dominant), reflective-regulatory (self-development dominant).

Thus, the value-semantic criterion characterizes the internal orientation of a practical psychologist, which is based on the internalization of humanistic values and awareness of the professional mission as a factor of social protection of the individual. It presupposes the formation of an ethical imperative (moral law) that determines the behavior of a specialist in complex professional conflicts, and a deep awareness of one's own responsibility for creating a safe value space in an educational institution.

The cognitive-methodological criterion reflects the level of development of analytical thinking and methodological culture of a practical psychologist, which is an indicator of the ability to systematically analyze educational situations. It includes not only theoretical knowledge, but also practical mastery of evidence-based practices, which allows the construction of original models of psychological support that will be effective in the current conditions of society's development.

The communicative-interaction criterion characterizes the skill of professional dialogue and the ability to interact productively in the multi-subject environment of an educational institution. It encompasses facilitation skills, empathy, and a high capacity for constructive conflict management based on mediation, which is critical for maintaining the psychological well-being of all participants in the educational process.

The reflective-regulatory criterion determines the ability of a practical psychologist to be aware of their own professional experience, self-correct, and maintain resilience in conditions of chronic stress. It includes a developed need for supervision, readiness for continuous professional training, and mastery of psychological self-hygiene techniques that prevent professional burnout and ensure long-term effectiveness of professional activity.

We view the development of the professional culture of a practical psychologist as a nonlinear, dialectical process of ascending from reproductive forms of activity to creative, culture-creating forms. This dynamic involves the evolution of a specialist from a passive executor of instructions to a subject who actively transforms the educational space. We define the following levels of development of the professional culture of a practical psychologist in an educational institution.

Reproductive level: at this stage, the professional culture of a specialist is characterized by a predominant focus on the formal performance of job duties and adaptation to the existing conditions of the educational institution. A practical psychologist acts within the framework of standard diagnostic procedures and responds to requests from the administration without conducting an in-depth analysis of the systemic causes of psychological problems. The impact on the quality of the educational environment is fragmented and limited to individual consultations.

Constructive level: the specialist moves on to initiating and developing their own psychological support programs aimed at solving specific problems of the educational community. At this level, the practical psychologist actively uses systematic analysis tools to influence the psychological climate in educational and pedagogical groups. Professional activity is aimed at constructive interaction with all participants in the educational process to ensure stable quality of interaction and psychological well-being.

Creative level: this is the highest level of professionalism, at which the practical psychologist becomes the ideologist of the organizational culture of the educational institution. The specialist does not simply respond to requests, but designs a security ecosystem and implements innovative models of trust, mediation, and partnership. The practical psychologist acts as an expert in matters of strategic development of the educational process, transforming the basic values of the institution on the principles of humanism and human-centeredness.

It should be noted that the implementation of our concept of developing the professional culture of a practical psychologist at an institution should take place at the micro, meso, and macro levels of the educational institution's ecosystem, which fully complies with the international standards of the OECD Learning Compass 2030 (OECD, 2019, pp. 1–12).

Micro level: direct interaction with the student, aimed at supporting the individual trajectory of development and the formation of subjectivity.

Meso level: harmonization of relations in the system “students – parents/guardians – teaching staff,” which is aimed at coordinating educational influences and building partnerships.

Macro level: transmission of humanistic professional values into a broad social context, formation of the institution's image as a safe space, and participation in the formation of community education policy.

Therefore, based on our scientific research, we can draw the following conclusions regarding the theoretical justification and conceptualization of the role of the professional culture of practical psychologists as a strategic factor in ensuring the quality

of the educational environment of educational institutions in the context of modern social transformations.

1. The professional culture of a practical psychologist is a holistic construct that acts as a fundamental factor in ensuring the quality of the educational environment, transforming it into a humanistic ecosystem. In the context of the current development of Ukrainian education, the professional culture of a practical psychologist is a system-forming factor that determines the vector of development of an educational institution.

2. The concept of the quality of the educational environment in modern scientific coordinates is a multidimensional construct that integrates philosophical, psychological, and sociocultural dimensions. The educational environment of an institution is a multilevel ecosystem where each element is in a state of constant interdetermination. The professional culture of a psychologist in this system acts as a mediator between its different levels.

3. The structural levels of the professional culture of a practical psychologist are worldview-diagnostic, intellectual-reflective, and technological-communicative, which are in a state of constant interaction.

4. The principle of psychological safety in the educational environment is both a fundamental principle and a key result of the implementation of the professional culture of a practical psychologist. It is implemented in three vectors: diagnostic and prognostic, corrective and developmental, and organizational and cultural.

5. Our concept is based on the identification of four interrelated criteria that reflect the structure and level of development of a specialist's professional culture: value-semantic (axiological dominant), cognitive-methodological (intellectual dominant), communicative-interactive (interaction dominant), reflective-regulatory (self-development dominant).

6. We consider the development of the professional culture of a practical psychologist to be a nonlinear, dialectical process characterized by three levels: reproductive, constructive, and creative. The effectiveness of the professional culture of a psychologist is manifested in its ability to act as a subject of culture creation, harmonizing the interaction of participants in the educational process at all levels of the educational space.

The prospects for our further research are the development of a methodology for the formation of the professional culture of a psychologist in the context of ensuring the quality of the educational environment.

AFTERWORD

The current stage of development of educational theory and practice is characterised by a fundamental rethinking of the ontological status of the category of "quality of education". This monograph is based on the realisation that ensuring the quality of professional and higher education can no longer be viewed as a linear achievement of fixed standards. Instead, the authors propose a systemic-synergistic model, where quality is seen as a *dynamic, multi-level process* that is in a state of permanent transformation. The methodological framework of the study integrates several fundamental approaches: an *institutional approach*, which allows for the analysis of changes in formal and informal rules of the game in the educational space; an *ecosystem approach*, according to which institutions of vocational and professional pre-higher education are part of a complex network of interaction between the state, the labour market and civil society; an evidence-based approach, which involves making management decisions based on verified data and empirical research results.

One of the central themes of the monograph is an analysis of the impact of the fourth industrial revolution on the architecture of educational systems. The authors argue that *digital transformation* is no longer just an instrumental addition but has become a basic methodological condition for the existence of modern vocational and professional pre-higher education. Particular attention is paid to the introduction of predictive analytics and artificial intelligence technologies in quality management. The study substantiates that the use of machine learning algorithms makes it possible to ensure precise monitoring of individual educational trajectories, to predictively identify systemic deficits in

competency profiles at early stages of learning, and optimise the feedback architecture in the system of interaction between educational institutions and key stakeholders. The use of machine learning algorithms enables: monitoring of individual educational trajectories; identification of systemic deficits in competency profiles at early stages of learning; optimising feedback between stakeholders and institutions of vocational and professional pre-higher education. At the same time, the monograph raises critical discussion about the ethical and methodological challenges of digitalisation. Issues of data confidentiality, algorithmic bias, and the need to preserve human agency in the context of automated management cycles are raised. Technology is seen as a powerful catalyst for development that requires strict value-based and regulatory oversight.

In the context of the globalisation of education, the authors of the monograph emphasise the growing importance of *flexibility and adaptability*. Traditional rigid qualification frameworks are giving way to dynamic models based on learning outcomes. This means that quality assurance processes are moving beyond local institutions. Scientific analysis confirms that the current quality of vocational and professional pre-higher education directly correlates with the level of international and sectoral convergence. The recognition of learning outcomes achieved in formal, non-formal and informal education is becoming a prerequisite for the sustainable development of human capital. The sectoral models of professional training developed in the monograph demonstrate that effective quality assurance is only possible if educational programmes are synchronised with professional standards and the requirements of the transnational labour market. This approach legitimises the concept of *lifelong learning* as a key indicator of the quality of the modern education system.

The methodological innovation of the study is the rethinking of the "human dimension" in the quality system. The authors of the monograph argue that no technological or institutional innovation can ensure sustainable results without taking into account the professional agency of teaching staff. *Agency* is understood as the ability of a teacher to be an active agent of change, rather than merely an executor of regulatory requirements. The monograph provides a detailed analysis of such components as: the culture of professional collaboration; career counselling and support; and a supportive

environment. This underscores the fundamental thesis of the study: the technological change in education is effective only if it is accompanied by the advanced development of professional culture and the strengthening of the institutional capacity of vocational and professional pre-higher education institutions. The monograph not only summarises previous research, but also formulates a strategic programme for the future. Scientists from the National Academy of Education Sciences of Ukraine identify a number of priority areas that will shape the development strategy for vocational and professional pre-higher education in the next decade: transition to fully data-driven management strategies; research into mechanisms for developing green and digital competencies in students; study of complex symbiotic structures combining the academic sector, production capacities and regional self-government bodies. International scientific cooperation plays a special role in this process. The authors argue that cross-border academic dialogue is not only a means of exchanging experience, but also a powerful tool for verifying scientific hypotheses and scaling up best educational practices.

Thus, the results of the presented monographic study allow us to conclude that quality assurance in the field of vocational and professional pre-higher education has evolved from a control function into a complex ecosystem strategy, according to which the transition from a “culture of control” to a “culture of quality” is ensured, where the latter is interpreted as a continuous social practice, integrated into the daily activities of all participants in the educational process. It is a continuous cycle of reflection, innovative search and purposeful improvement, implemented at the intersection of technological capabilities and humanistic values. The conceptual approaches, methodological principles and practical recommendations formulated in the work create a solid foundation for the modernisation of educational policy. They are aimed at designing sustainable, inclusive and future-oriented systems capable of responding effectively to the ever-changing demands of society and ensuring a high level of competitiveness for future specialists in a global context.

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MONOGRAPH

QUALITY ASSURANCE OF VOCATIONAL AND PROFESSIONAL PRE-HIGHER EDUCATION IN THE CONTEXT OF CONTEMPORARY CHALLENGES

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The monograph “Quality assurance of vocational and professional pre-higher education in the context of contemporary challenges” presents a comprehensive study of the theoretical, methodological, and institutional foundations for the development of the educational sphere in a period of global transformation. In this work, the quality of education is conceptualised through the prism of human capital development and European political guidelines. Based on a comparative analysis of EU countries' systems, the implementation potential of leading European practices for the modernisation of Ukrainian education is determined. The authors reveal the role of institutional mechanisms and digital tools in ensuring the quality of education, emphasising the use of intelligent systems, educational data analytics and artificial intelligence as key factors in the renewal of educational management. Particular attention is paid to issues of transnational mobility, recognition of learning outcomes, sustainable development priorities and post-crisis transformation strategies. A separate section of the study is devoted to innovative approaches to professional training, in particular the formation of “green” skills, the energy-efficient component of educational content, and the introduction of project-based learning. The publication is intended for researchers, managers in the field of vocational and professional pre-higher education, teachers, and educational policy developers.

Монографія «Забезпечення якості професійної та фахової передвищої освіти в умовах сучасних викликів» презентує комплексне дослідження теоретичних, методологічних та інституційних засад розвитку освітньої сфери в період глобальних трансформацій. У роботі якість освіти концептуалізується крізь призму розвитку людського капіталу та європейських політичних орієнтирів. На основі порівняльного аналізу систем країн ЄС визначено імплементаційний потенціал провідних європейських практик для модернізації української освіти. Автори розкривають роль інституційних механізмів та цифрових інструментів у забезпеченні якості навчання, акцентуючи на використанні інтелектуальних систем, аналітики освітніх даних та штучного інтелекту як ключових чинників оновлення освітнього менеджменту. Особливу увагу приділено питанням транснаціональної мобільності, визнанню результатів навчання, пріоритетам сталого розвитку та стратегіям посткризової трансформації. Окремий блок дослідження присвячено інноваційним підходам до професійної підготовки, зокрема формуванню «зелених» навичок, енергоефективному складнику змісту освіти, впровадженню проєктного навчання. Видання розраховане на науковців, управлінців у сфері професійної та фахової передвищої освіти, викладачів та розробників освітньої політики.

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