Chapter 2. THE DIGITAL ECONOMY, MANAGEMENT, AND INNOVATIVE LEADERSHIP MODELS

2.1. ASSESSMENT OF POSITIVE DEVELOPMENTS IN VOCATIONAL EDUCATION IN THE CONTEXT OF THE DIGITAL ECONOMY AND INFORMATION SOCIETY

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The rapid entry of humanity into the era of the digital economy and the development of the information society have fundamentally transformed the modern labor market and the mechanisms for forming professional competencies (Hetmańczyk, 2024; OECD, 2024a). Global digitalization has ceased to be merely a technological trend and has become a defining factor in economic growth, social mobility, and structural transformation of society (Țarcă et al., 2024). In this context, vocational education becomes a critically important component of the human capital system, as it shapes specialists capable of effectively functioning in high-tech environments and responding to constantly changing market demands (Xu et al., 2024). The relevance of this research topic is driven by the need to rethink the role of vocational education as a dynamic and flexible system that not only adapts to current economic needs but also anticipates future demands, preparing specialists with a fundamentally new set of competencies.

The digital economy places high demands on workforce qualifications, particularly the ability to quickly master modern technologies and work with large volumes of data (Đorđević et al., 2025; Tee et al., 2024). Today, professional expertise is no longer limited to narrow specialized skills (hard skills) but involves the integration of digital competencies, critical thinking, collaboration skills, and the ability to apply artificial intelligence and data analytics tools (Radkevych et al., 2025). This creates a number of significant challenges for the education system: there is a notable gap between the pace of technological advancement in the industrial and business sectors and the inertia of traditional educational programs. Many vocational education institutions face the moral obsolescence of their material and technical base, limited opportunities for teachers in the field of digital competence, and insufficient integration of practical digital skills into the learning process (Bazyl et al., 2024b).

Modernizing vocational education has become a strategic priority of state policy. This involves not only the introduction of modern equipment, digital platforms, and distance learning but also a deep structural overhaul of the system: the development of innovative professional standards, the creation of virtual laboratories, the updating of teacher training methodologies, and the integration of learning with business practice (Pryhodii et al., 2025). Assessing positive shifts in this area allows for evaluating the effectiveness of current reforms, identifying the most successful models of interaction between educational institutions and stakeholders, and forecasting future directions for vocational school development. Key benchmarks include lifelong learning, the adaptability of specialists to change, and the ability of the education system to prepare personnel that meets the demands of the modern digital economy and the conditions of the information society.

The transformation of the modern world order is based on the transition from an industrial model to an information society, where knowledge, information, and innovative technologies become key production resources (Bazyl et al., 2023; Ostenda et al., 2018). In the scientific discourse, the information society is defined as a stage of civilizational development in which the majority of the workforce is engaged in the production, processing, storage, and dissemination of information. This society is characterized by a high level of interaction between technology, culture, and the economy, creating new forms of social and labor organization. A logical continuation of this process has been the formation of the digital economy, which integrates technologies into all spheres of human and societal activity (Bazyl et al., 2024a).

The digital economy is characterized by the widespread use of digital technologies as a key factor of production. It encompasses not only the information technology sector but also a complex of economic, social, and cultural relations that emerge in the process of applying digital tools and

communications (Hurzhii, & Pryhodii, 2025). It affects business models, management practices, innovation processes, and methods of learning.

For vocational education, this implies a radical paradigm shift: knowledge is no longer a static resource acquired once and used throughout life. In the digital economy, knowledge becomes a dynamic flow that requires continuous updating and verification. This imposes new requirements on the structure of educational programs, teaching methodologies, and the competencies of teaching staff (Bazyl et al., 2024b; Pryhodii et al., 2025).

In the era of digitalization, vocational education ceases to be merely a mechanism for reproducing the workforce and becomes an active driver of innovation and technological development. One of the key concepts is "Education 4.0," which correlates with the concept of "Industry 4.0" (Жук, 2024). It entails several fundamental principles:

Personalized learning – the use of adaptive algorithms and platforms to create individual educational trajectories that take into account students' prior knowledge and career goals (*OECD*, 2025; *European Commission*, 2022);

Agility – the ability of the educational system to respond quickly to the emergence of new technology stacks, professions, and labor market requirements (*OECD*, 2024b; *OECD*, 2025);

Co-creation – the shift from passive knowledge reception to active creation of content and projects in a digital environment (Жук, 2024).

An important model is the Triple Helix, which describes the interaction between universities, business, and government (Cai, & Lattu, 2022). In the digital economy, this model expands into the Quadruple Helix, where the fourth element is civil society and the digital environment (Carayannis, Barth, & Campbell, 2012). In this system, vocational education acts as a mediator, translating the demands of industry and the labor market into specific competencies for future professionals.

International experience, particularly from EU countries and the OECD, demonstrates a systemic approach to the digitalization of education and the development of professional competencies (*OECD*, 2023; *OECD*, 2024b).

The *European Digital Competence Framework* (DigComp) defines 21 competencies across five key areas: information literacy, communication and collaboration, content creation, safety, and problem solving. Vocational education in the EU integrates these competencies into all curricula (*European Commission*, 2022).

The *Digital Europe Programme* emphasizes the training of highly specialized professionals (e.g., Data Scientists, AI Architects) while simultaneously ensuring a basic digital level for vocational workers (*European Commission*, 2021).

OECD studies (Education at a Glance) show that job automation shifts the focus of vocational education toward soft skills and higher-order digital skills (*OECD*, 2023; *OECD*, 2025).

In Ukraine, the digitalization of vocational education is implemented through the "Digital State" concept and the Diia.Education platform (*Дія.Освіта*, н.д.). A positive example is the creation of digital hubs at colleges and the introduction of dual education, where digital competencies are acquired directly at the workplace in IT-oriented companies (Radkevych, & Pryhodij, 2025). At the same time, a challenge remains: overcoming the digital divide between urban and rural educational institutions and ensuring equal access to modern digital resources (*OECD*, 2023).

By "positive shifts" in vocational education, we understand changes that bring learning outcomes closer to the requirements of the digital labor market. The main evaluation criteria are:

Across-the-board digitalization of competencies – integration of digital skills into vocational subjects (Ghosh, & Ravichandran, 2024; Radkevych, & Pryhodii, 2025). For example, future construction specialists acquire BIM technologies, while agronomists learn drone management and IoT sensors;

Program innovation – emergence of new interdisciplinary specialties (bioinformatics, robotics, industrial cybersecurity). Programs become modular and easily updatable (Bazyl et al., 2024b);

Flexible educational pathways (Micro-credentials) – the ability to obtain certificates for specific skills without completing a full study cycle (Гуржій та ін., 2025);

Integration of IT tools into educational management – automation of document workflows, implementation of LMS and ERP systems, which increases transparency and efficiency of processes (Ghosh, & Ravichandran, 2024; Radkevych, & Pryhodii, 2025).

The role of the teacher is transforming from a "source of information" to a tutor and facilitator capable of working with VR and AR technologies. Vocational education becomes a dynamic ecosystem, where effectiveness is evaluated not only by the number of diplomas but by graduates' adaptability and their ability to create added value in a digital environment (*World Economic Forum*, 2020).

In the context of evaluating positive shifts in vocational education, a study was conducted using a combined methodological approach, integrating quantitative analysis, comparative analysis, and case studies, with the aim of comprehensively examining positive developments in vocational education within the framework of the digital economy and information society.

Quantitative analysis was applied to process data obtained from surveys of 378 learners and 46 teachers, covering multiple regions of Ukraine and various specializations. The survey included questions regarding the use of digital technologies in the learning process, the level of digital competencies, participation in internships, and the assessment of educational program effectiveness. Statistical processing included calculating frequencies, percentages, averages, and correlations between variables, allowing key trends and interrelations to be identified.

Comparative analysis was used to juxtapose national practice with international standards and recommendations from the EU and OECD. Key data sources included statistical reports of international organizations, official documents of the European Digital Competence Framework (DigComp), the Digital Europe Programme, OECD reports (Education at a Glance), as well as results of national initiatives such as Diia.Education and data on the creation of digital hubs in colleges. This allowed for an assessment of the effectiveness of implemented changes and identification of gaps compared to international practice.

Case studies were applied for in-depth analysis of individual educational institutions where innovative approaches were implemented: use of VR/AR laboratories, modular programs, micro-credentials, and dual education models. This approach made it possible to reveal practical results of digitalization, assess its impact on student motivation, development of digital competencies, and graduates' readiness to work in a high-tech environment.

For systematization and clarity of the study results, the main criteria for evaluating positive shifts in vocational education were identified (Table 1).

Table 1. Criteria for Evaluating Positive Shifts in Vocational Education

No.	Criteria for Evaluating Positive Shifts	Examples / Components
1	Integration of Digital Technologies into the Learning Process	Online platforms, distance learning, VR/AR
2	Modernization of Educational Programs	Flexible modules, STEM and IT specializations
3	Collaboration with IT Companies and Business	Industrial internships, joint projects
4	Professional Development of Teachers	Digital technologies, media literacy, digital competencies

Thus, the research methodology combined quantitative analysis, comparative research, and case studies, allowing for the assessment of both general development trends and specific outcomes of innovation implementation in vocational education, providing a comprehensive and representative analysis of the current state and future prospects of workforce training for the digital economy.

Within the framework of the study, surveys and observations were conducted among students and teachers of vocational education institutions to evaluate the implementation of positive changes in the vocational education system in the context of the digital economy and information society. Data analysis allows for identifying the main trends characterizing the modernization of the educational process and its impact on the quality of specialist training.

1. Integration of Digital Technologies into the Learning Process. The implementation of online platforms, distance learning, and VR/AR technologies is one of the key changes. The survey showed

that 82% of students actively use online platforms for completing practical tasks, and 76% of teachers assess their effectiveness as high or very high. Observations revealed that 45% of practical laboratory sessions are now conducted using VR simulators or virtual learning environments, significantly enhancing the level of practical training without additional material costs.

The survey also demonstrated that students note improved accessibility of learning materials and the ability to work at their own pace: 58% of students stated that digital tools allow them to master the material more deeply compared to traditional classes. Teachers emphasized the importance of interactive elements: 71% of respondents believe that VR and AR technologies significantly enhance student motivation and engagement in the learning process (Table 2).

Table 2. Use of Digital Technologies in the Learning Process (Survey Results)

Category	Students (n = 378)	Teachers (n = 46)
Actively use online platforms	310 (82%)	35 (76%)
VR/AR in practical lessons	246 (65%)	33 (71%)
Distance learning as the main format	198 (52%)	24 (52%)
Positive impact on motivation	220 (58%)	33 (72%)

2. The development of digital competencies among students and teachers is a key factor in the modernization of education. The survey showed that 67% of students believe their digital skills have significantly improved over the past two years, while 74% of teachers reported an increase in their digital literacy after participating in training on VR/AR, LMS, and educational platforms.

The practice of integrating digital skills into professional disciplines proved particularly effective. For example, future construction specialists master BIM technologies, agricultural students learn remote management of IoT sensors, and IT students develop and manage databases in cloud environments. 59% of students confirmed that these skills are directly applied during practical internships, positively impacting their readiness for real-world work.

3. Modernization of educational programs. Changes in educational programs include the introduction of flexible modules, STEM, and IT specializations, allowing the learning process to be rapidly adapted to labor market requirements. The survey showed that 71% of students consider the programs modern and aligned with the needs of the digital economy. Among teachers, 78% noted that the modular program structure improves the efficiency of planning and teaching.

The introduction of micro-credentials has become an additional adaptation tool: 64% of students received certificates for specific digital skills during the past academic year, directly enhancing their competitiveness in the labor market.

4. Collaboration with businesses and industrial internships has become an important component of practical training. The survey showed that 69% of students completed internships at partner companies, while 83% of teachers highlighted the effectiveness of this approach in integrating practical digital skills.

Comparative analysis showed that students who completed internships rated their readiness for work in a company at an average score of 4.2/5, while students without internships rated themselves at 3.1/5 (Table 3).

Table 3. The Impact of Internships and Business Collaboration on Work Readiness

Indicator	Students with Internships	Students without Internships
Average Work Readiness Score	4.2/5	3.1/5
Use of Digital Tools in Practice	85%	47%
Perceived Benefit for Professional Development	88%	52%

5. Analysis of Effectiveness and Impact on the Quality of Vocational Training. The analysis of the collected data showed that the integration of digital technologies and the modernization of educational programs positively influenced the level of students' practical training. 76% of surveyed students reported improved understanding of professional processes, while 71% of teachers noted an increase in students' success in using digital tools.

Flexible modules and micro-credentials proved especially effective, allowing students to quickly acquire relevant digital competencies without waiting for the completion of the full educational cycle. This contributes to greater adaptability of graduates and their ability to integrate into professional environments.

6. Challenges and Limitations of Implementing Changes. Despite positive shifts, significant challenges remain: the digital divide between urban and rural educational institutions limits access to modern technologies and online resources; insufficient digital competence among teachers – 26% of surveyed instructors feel the need for additional training to work with VR/AR and LMS; material and technical constraints – about 31% of institutions have outdated equipment, preventing full implementation of digital methods; lack of integration with business in some regions – 18% of students had no access to internships or partner programs in their region.

Thus, despite noticeable progress in implementing digital technologies and modernizing educational programs, achieving a high level of graduate readiness for the digital economy requires additional investment in infrastructure, teacher training, and expansion of partnerships with business and international educational organizations.

The conducted research allows us to state that vocational education in the context of the digital economy and information society is undergoing profound transformation. Digitalization has ceased to be merely an auxiliary learning tool and has become a fundamental condition for developing a competitive specialist (Bazyl et al., 2024b; Жук, 2024). A key conclusion is that the success of educational reforms today is determined not only by the presence of modern computer equipment but primarily by the depth of integration of digital competencies into professional standards, the system's ability to adapt to the demands of a dynamic labor market, and the readiness of teaching staff to apply innovative technologies (*European Commission*, 2022; Hurzhii, & Pryhodii, 2025).

Analysis of surveys and observations of 378 students and 46 teachers confirmed that the most effective positive shifts are: the implementation of the dual education model with a focus on IT competencies, ensuring practical acquisition of digital tools at the workplace; the use of cloud learning environments and LMS, which increases accessibility of materials and enables personalized educational trajectories; and the integration of micro-credentials and flexible modules, which allow rapid updating of knowledge and competencies in response to new technological demands (Ghosh, & Ravichandran, 2024; Гуржій та ін., 2025). These measures contribute to higher employability of graduates and enhance their capacity to work productively in conditions of high-tech uncertainty (*OECD*, 2025; Țarcă et al., 2024).

Based on the results obtained, we propose the following recommendations for key stakeholders in the educational process.

For government policy and educational institutions, several priorities should be emphasized. First, the implementation of unified digital platforms, including the creation of a national LMS ecosystem, which allows for the consolidation of learning resources, ensures transparency in assessment, and provides students with access to certified digital materials (*Дія.Освіта*, н.д.; *European Commission*, 2021). Second, regular updates of curricula are necessary, at least every two years, with mandatory involvement of representatives from the technology sector; priority should be given to transversal digital competencies and soft skills. Third, systematic professional development for educators, including training in VR/AR, gamification of learning, digital mentoring, and data management, ensures the effective implementation of innovations in the educational process (Pryhodii et al., 2025; Hetmańczyk, 2024).

For business and labor market integration, two key directions are important. The creation of joint competence centers, including "advanced learning" laboratories, allows students to master technologies that are only being introduced in production and fosters closer interaction between education and industry (Cai, & Lattu, 2022; Carayannis et al., 2012). Validation of non-formal education ensures recognition of learning outcomes gained through massive online courses (MOOCs) and certification programs within professional standards, enhancing graduates' mobility and competitiveness (Radkevych, & Pryhodii, 2025; Xu et al., 2024).

Future research prospects include analyzing the impact of artificial intelligence on the structure of professional qualifications, developing models for forecasting labor market needs in the context of automation, and examining the ethical aspects of data usage and cybersecurity in digital educational ecosystems (*OECD*, 2024b; Radkevych et al., 2025).

Thus, vocational education becomes a dynamic ecosystem, where innovative methodologies, digital competencies, and close interaction with the labor market determine the effectiveness of preparing future specialists and the competitiveness of graduates in the global market.

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