SECTION 1.
Artificial Intelligence and Digitalization of the Economy: Integration of European Approaches into Ukrainian Realities

DANYLENKO Olena,
Ph.D. in Economics, associate professor, associate professor of Department of Socioeconomics and Personnel Management,
Kyiv National Economic University
named after Vadym Hetman,
Kyiv, Ukraine
ORCID: https://orcid.org/0000-0002-1334-2240

1.1. EUROPEAN EXPERIENCE IN THE APPLICATION OF ARTIFICIAL INTELLIGENCE IN EDUCATION AND THE KNOWLEDGE ECONOMY

Introduction. Education and the knowledge economy, which are grounded in the creation, dissemination, and utilization of knowledge and information, constitute a key driver of competitiveness and sustainable development in modern states. A significant share of GDP in these economies derives from activities related to generating, processing, storing, and distributing information and know–how. In this context, artificial intelligence (AI) offers unprecedented opportunities to enhance efficiency, spur innovation, and generate new forms of value. The European Union, recognizing this potential, has been actively developing and implementing strategies and regulatory frameworks to foster the responsible and effective deployment of AI across various economic sectors, including education and the knowledge economy.

The European Union's experience in the AI domain provides a valuable roadmap for Ukraine, which aspires to integrate into the European economic area and to cultivate its own knowledge–based potential. Studying and adapting successful European practices can significantly accelerate Ukraine's digital transformation and bolster the competitiveness of its businesses, educational institutions, and research organizations.

Summary of Key Findings. Since 2018, the European Union has been systematically establishing a comprehensive legislative framework for AI governance. Aware of both the immense opportunities and the potential risks associated with AI development and deployment, the EU strives to craft a legal environment that promotes innovation, ensures the ethical use of technology, and safeguards fundamental citizens' rights (see Table 1).

Table 1

Stages in the Development of the Legislative Framework for AI Regulation in the EU

Years	Key Milestones in EU AI Legislation and Governance
1	2
2025	– April 9: AI Coalition Action Plan published
	– March 12: Six additional consortia selected to build European AI research "factories"
	– February 4: Adoption of Recommendations on prohibited AI practices
	– February 11: President von der Leyen launches "Invest AI" at the AI Action Summit in Paris
	– December 10: Seven consortia chosen to establish AI research factories in the EU
2024	– September: Start of drafting the Code of Practice for general-purpose AI
	– September: Companies sign EU commitments to the AI Pact (Component II)
	– August 1: Entry into force of the Law on AI

Continuation of Table 1

1	2
	– April: Establishment of the European AI Office
	– March: Innovative AI Package to support startups and small and medium-sized businesses with AI
2023	– December: Political agreement on the AI Act reached by co-legislators
	– June: European Parliament agrees its negotiating position on the AI Act
2022	– December: Council confirms its general approach on the AI Act
	– September: EC Proposal for a Directive on liability for AI
	– June: Launch of the first AI regulatory sandbox in Spain
2021	– December: Committee of the Regions, opinion on the Law on AI
	– December: European Central Bank, Opinion on the Law on AI (.PDF)
	– November: Council of the EU: the EU Council Presidency announced a compromise text on the Artificial Intelligence Act (PDF)
	– November: High-Level Conference on Artificial Intelligence – From Ambition to Action (3rd Assembly of the European AI Alliance)
	– November: European Economic and Social Committee issues its Opinion on the AI Act
	– June: Public consultation on civil liability – adaptation of liability rules to the digital age and artificial intelligence
	– June: European Commission – Proposal for a Regulation on Product Safety
	– April: European Commission – Communication on Promoting a European Approach to AI
	– April: European Commission – Proposal for a Regulation establishing harmonized rules on AI
	– April: European Commission – Updated Coordinated Plan on AI

Continuation of Table 1

1	2
2021	– April: European Commission – Impact assessment of AI regulation
2020	– October: 2nd Assembly of the European AI Alliance
	– July: Initial impact assessment – Ethical and legal requirements for artificial intelligence
	– July: High-Level Expert Group on AI – Final Assessment List for Trustworthy AI (ALTAI)
	– July: High-Level Expert Group on AI – Sectoral Recommendations for Trustworthy AI
	– February: European Commission – White Paper on AI: A European Approach to Excellence and Trust
	– February: Public consultation on the European approach to excellence and trust in artificial intelligence
2019	– December: High-Level Expert Group on Artificial Intelligence – Pilot of the Assessment List for Trustworthy AI
	– June: First Assembly of the European AI Alliance
	– June: High-Level Expert Group on Artificial Intelligence – Policy and Investment Recommendations on AI
	– April: European Commission – Communication “Building Trust in Human-Centric AI”
	– April: High-Level Expert Group on AI – Ethics Guidelines for Trustworthy AI
2018	– December: European Commission – Coordinated Plan on AI
	– December: European Commission (Press release) – “Artificial Intelligence Made in Europe”
	– December: European Commission – Communication “Artificial Intelligence Made in Europe”
	– December: Stakeholder consultations on the draft ethics guidelines for Trustworthy AI
	– June: Launch of the European AI Alliance
	– June: Establishment of the High-Level Expert Group on AI

Continuation of Table 1

1	2
	– April: Press release – "Artificial Intelligence for Europe"
	– April: Communication – "Artificial Intelligence for Europe"
	– April: Staff working document – "Responsibility for Novel Digital Technologies"
	– April: Declaration on Cooperation in the Field of AI
	– March: Press release – Establishment of the High-Level Expert Group on AI and launch of the European AI Alliance

Source: summarized by the author based on [1]

On the official website of the European Union, the glossary defines AI as follows: "*Artificial intelligence (AI)* refers to systems that display intelligent behavior by perceiving their environment and taking actions, with some degree of autonomy, to achieve specific goals. AI-based systems may be purely software-based, operating in a virtual environment (for example, voice assistants, image-analysis software, search engines, speech and facial recognition systems), or AI may be embedded in hardware devices (for example, advanced robots, autonomous vehicles, drones, or Internet-of-Things applications)" [2].

In 2020, the EU's High-Level Commission on Artificial Intelligence published its White Paper on Artificial Intelligence [3], setting out policy options to ensure the trustworthy and safe development of AI in Europe. The White Paper emphasized the critical importance of a European approach – one that prioritizes overcoming the shortfall in digital competencies and skills. This emphasis was also reflected as a cornerstone of the updated European Skills Agenda.

As part of its digital strategy, the European Commission proposed a comprehensive legal framework for AI – the AI Act, which entered into force on August 1, 2024 [4]. The Act establishes mandatory requirements for "high-risk" AI systems across a number of domains, including education and vocational training. It represents the world's first horizontal legal instrument grounded in the EU's regulatory and policy

work on AI and data, encompassing the 2019 Ethics Guidelines for Trustworthy AI (issued by the AI High-Level Expert Group – AI HLEG), the General Data Protection Regulation (GDPR), and the proposed Data Act.

The EU AI Act's key provisions include:

– Setting EU-wide minimum requirements for AI systems based on a risk-management approach;

– Protecting fundamental rights, the rule of law, democracy, and the environment from potential harms posed by AI;

– Classifying AI systems into four risk levels: unacceptable risk, high risk, limited risk (requiring transparency obligations), and minimal or no risk;

– Determining the Act's success by its ability to balance potential benefits and challenges, and by how swiftly industry, public authorities, and civil society adapt to the new legal framework.

The AI Act aims to ensure that Europeans can trust what AI has to offer. While most AI systems are safe – or even beneficial – for society, certain applications carry risks that the EU must regulate to prevent adverse outcomes. In particular, the "black-box" nature of some AI decision-making processes can make it difficult to understand or predict their behavior. Existing EU legislation provides only partial protection; the AI Act fills these gaps by addressing AI-specific challenges.

Accordingly, the AI Act adopts a risk-based methodology, defining *four levels of AI risk*:

Level 1: *unacceptable risk* – these are all EU-banned artificial intelligence systems that are considered a clear threat to security, livelihoods, and human rights. "*The AI Act prohibits eight practices, namely*:

1. AI-driven harmful manipulation and deception.
2. AI-enabled exploitation of vulnerabilities.
3. Social scoring by public authorities.
4. Prediction or forecasting of individual criminal behavior.
5. Non-targeted scraping of the internet or video surveillance data to create biometric recognition databases.

6. Emotion recognition in the workplace or educational settings.
7. Biometric categorization to infer protected characteristics.
8. Real-time remote biometric identification for law enforcement purposes in public spaces" [4].

Level 2: *high risk* – these are uses of AI systems and technologies that may pose serious risks to health, safety, or fundamental rights. "*Such high-risk use cases include*:

– AI safety components in critical infrastructure (e.g., transport);
– AI systems used in education or vocational training that determine access to education or professional pathways (e.g., automated exam scoring);
– AI-based safety components in products (e.g., AI-assisted robotic surgery);
– AI tools for recruitment, workforce management, or access to self-employment (e.g., CV-screening software);
– AI systems used to grant access to essential private or public services (e.g., credit scoring);
– AI for remote biometric identification, emotion recognition, and biometric categorization (e.g., retrospectively identifying a shoplifter);
– Law-enforcement AI that may infringe fundamental rights (e.g., evidential assessment systems);
– AI for migration management, asylum processing, and border control (e.g., automated visa-application screening);
– AI in judicial and democratic processes (e.g., AI-assisted sentencing recommendations)" [4].

High-risk systems must comply with:

– Adequate risk-assessment, mitigation, and minimization systems;
– High-quality datasets to prevent bias and discrimination;
– Logging requirements to ensure traceability;
– Comprehensive documentation detailing system design and intended purpose;
– Clear and adequate developer information;
– Appropriate human oversight measures to minimize risk;
– High levels of reliability, safety, and accuracy" [4].

Level 3: *transparency risk* – these are AI applications that require transparency obligations to ensure public awareness and maintain trust. For instance, users interacting with AI chatbots must be informed that they are communicating with a machine. Moreover, developers of generative AI must clearly label AI-generated content, particularly deepfakes and AI-generated texts on matters of public importance.

Level 4: *minimal risk or no risk*. The AI Act does not regulate AI systems that pose minimal or no risk. Most AI applications currently in use across the EU fall into this category – examples include AI-enhanced video games and spam-filtering tools.

The establishment of this comprehensive legal framework for AI regulation is complemented by *an EU-wide innovation support ecosystem*. Through initiatives such as European Digital Innovation Hubs, AI factories, and the AI Skills Academy, the European Commission promotes AI research, innovation, and leadership in Europe [5].

At the core of these ecosystem initiatives is the creation of specialised institutions and facilities:

European Digital Innovation Hubs (EDIHs) are one-stop shops that assist companies in becoming more competitive in their business and manufacturing processes, products, or services by integrating digital technologies, including AI.

Testing and Experimentation Facilities (TEFs) are large-scale, specialized reference centers that help technology providers transition products from the laboratory to the market. They support full integration, testing, and experimentation of cutting-edge, mature AI technologies.

AI Factories (AI Factories) are specialized institutions designed to provide supercomputing capabilities for the development and training of advanced AI models. They will also foster talent development by offering upskilling, training, and reskilling programs for the relevant stakeholders in the AI ecosystem.

AI Regulatory Sandboxes (AIRS) offer controlled environments where innovators can trial AI systems under the supervision of National Competent Authorities (NCAs), receiving regulatory guidance and training that encourage both innovation and competitiveness.

AI-on-Demand Platforms offer access to a wide range of algorithms, tools, and expertise, as well as opportunities for knowledge sharing and collaboration. Key features of these platforms include a unified interface for exploring and importing AI datasets from multiple sources, enabling users to customize models and datasets and to conduct experiments within an open-source environment.

AI Skills Academy will serve as a one-stop shop for a suite of educational and training programs across two main streams:

– Skills for deploying and integrating AI, particularly generative AI into key economic sectors;

– Skills related to the operations and workflows of AI Factories.

The European Commission's commitment to developing AI-related skills and expertise is embodied in the forthcoming AI Skills Academy, which will prepare the workforce for the demands of an AI-driven future and ensure that Europe remains a leader in AI excellence. Upskilling efforts are a joint mission of the Commission's ecosystem initiatives, with European Digital Innovation Hubs and AI Factories also offering workforce training.

On the other hand, *the education sector itself holds significant potential for AI and data use*. This involves leveraging AI-processed data in teaching to enhance and personalize learning for groups or individual students, and to help educators and staff use data more effectively and securely.

Under the auspices of the European Commission and with the support of the High-Level Expert Group on AI and Data in Education and Training, *Ethics Guidelines for the Use of Artificial Intelligence and Data in Teaching and Learning* have been developed for educators [6]. These guidelines align with the AI Act and build on the EU's broader regulatory and policy framework for AI and data, including the GDPR and the proposed Data Act, which impose mandatory requirements on high-risk AI systems across multiple domains such as education and vocational training. They are tailored to the specific context of teaching and learning, offering educators both the necessary awareness-raising measures and

practical recommendations as they increasingly integrate AI into their pedagogical practice.

According to the *Digital Education Action Plan (2021–2027), the European Union has defined two strategic priorities*:

1. "To achieve the *Fostering High-Performing Digital Education Ecosystems*, needs:

– Robust infrastructure, connectivity, and digital equipment;

– Effective planning and development of digital capacities, including modern organizational capabilities;

– Digitally competent and confident teachers, trainers, and educational staff;

– High-quality content, user-friendly tools, and secure platforms that respect privacy and ethical standards.

2. *Enhancing Digital Skills and Competences for the Digital Age*:

2.1. *Ensuring Basic Digital Skills and Competences from an Early Age*:

– Digital literacy, including managing information overload and identifying misinformation;

– Computer science education;

– Solid understanding of data-intensive technologies such as AI.

2.2. *Promoting Advanced Digital Skills*:

– Increasing the number of digital specialists;

– Encouraging more girls and women to pursue careers in digital sciences and related fields" [6].

To implement them, it is proposed to get rid of prejudices regarding the possibilities of using AI and data in teaching and learning in the field of education. The most common misconceptions regarding AI, its short-term and long-term impact on education systems and society in general, are considered to be the following:

• "*AI is too complex to understand*": Many non-technical educators are deterred by AI jargon. Rather than mastering every technical detail, teachers should understand AI's core mechanisms, limitations, and how to apply AI tools safely and ethically to support teaching and learning.

- "*AI has no role in education*": AI is already transforming how we learn, work, and live – and education is no exception. Everyone should be empowered to contribute to and benefit from AI-driven innovation.
- "*AI is not inclusive*": While AI can exacerbate existing inequalities if poorly designed, it also has the potential to improve access and engagement for underrepresented learners, notably by providing tailored resources for students with disabilities or special needs.
- "*AI systems cannot be trusted*": As AI augments or replaces certain human tasks, concerns arise around fairness, transparency, and data protection. Although existing EU legislation offers partial safeguards, the AI Act ensures that "high-risk" systems – those capable of significant harm to health, safety, or fundamental rights – are developed under mandatory risk-mitigation measures. Educational authorities and schools must be able to verify AI compliance and focus on ethical AI use to support both teachers and learners while adhering to data-protection rules.
- "*AI will undermine the role of the teacher*": Rather than replacing educators, AI can free them from repetitive administrative duties and enable more creative, problem-based, and collaborative learning experiences, tasks beyond AI's current autonomous capabilities. The teacher's role is thus likely to evolve and expand, provided AI applications are developed and deployed with an emphasis on supporting – not supplanting – human instruction [summarized from: 6].

Contrary to these misconceptions, the use of AI in schools, universities, and vocational institutions across Europe is growing. AI supports teaching, learning, and assessment practices. However, evidence-based research on AI's educational impact remains limited, underscoring the need for a critical and monitored approach to its implementation. The types of artificial intelligence systems used for teaching, learning, assessment, and school administration usually distinguish between "student", "teacher", and "system-oriented" AI systems.

Options for using AI and data in education in the EU are:

– *Student-facing*: using AI to teach students;

– *Student support*: Using AI to support student learning;

– *Teacher-facing* (supporting educators): using AI to support teachers;

– System-facing (assisting administrative or systemic planning and diagnostics) [summarized from: 6].

Table 2 presents *examples of AI and data uses in EU education*, illustrating how AI systems can assist teachers and students in teaching, learning, and assessment.

Table 2

Examples of using AI and data capabilities in the European Union's education sector

Using AI to teach students	
1	2
Smart tutoring	The student completes a step-by-step sequence of tasks and receives individual instructions or feedback without requiring teacher intervention.
Dialog learning systems	The learner completes a sequence of tasks step by step through natural language conversation. More advanced AI systems can automatically adapt to the level of engagement to keep the learner motivated and on task.
Learning the language of the program	AI-powered learning applications are used in formal and informal education contexts. They support learning by providing access to language courses, dictionaries, and provide real-time automated feedback on pronunciation, comprehension, and fluency.
Search learning environment	Students are offered several ideas to help them identify their own paths to achieving their learning goals.
Formal assessment of written performance	Curricula provide students with regular automated feedback on their written work.

Continuation of Table 2

1	2
Collaborative learning based on AI	Data about each student's work style and past performance is used to divide them into groups with similar ability levels or a suitable combination of abilities and talents. AI systems provide input/suggestions on how the group works together by tracking the level of interaction between group members.
Using AI to support teachers	
Overall assessment of written performance, essay assessment	Using AI to automatically assess and grade students' written work. AI and machine learning techniques identify characteristics such as word usage, grammar, and sentence structure to assess and provide feedback.
Monitoring student forums	Keywords in student forum posts trigger automatic feedback. Discussion analytics provide insights into student forum activity and can highlight students who may need help or are not engaging as expected.
AI-based teaching assistants	AI agents or chatbots provide answers to frequently asked questions from students with simple instructions and directions. Over time, the AI system is able to expand the range of answers and options provided.
Using AI to support teachers	
Recommendations for pedagogical resources	AI-based recommendation engines are used to recommend specific learning activities or resources based on each student's preferences, progress, and needs.
Intelligent analysis of educational data for resource allocation	Schools collect data about students, which they analyze and use to plan the optimal allocation of available resources for tasks such as creating student groups, assigning teachers, scheduling, and identifying students who may need additional learning support.

Continuation of Table 2

1	2
Using AI to support teachers	
Diagnosis of learning difficulties	Using learning analytics, cognitive skills such as vocabulary, listening, spatial reasoning, problem solving, and memory are measured, which helps diagnose learning difficulties, including hidden problems that are difficult for a teacher to detect but can be detected by AI systems at an early stage.
Consulting services	AI-driven advising services provide continuous prompts and options for designing personalized educational pathways. Users can build a competency profile, encompassing their prior qualifications and individual interests. By combining these data with an up-to-date course catalog or information on available learning opportunities, the system can generate relevant learning recommendations using natural language processing.

Source: summarized by the author based on [6]

In line with Priority 1: Fostering High-Performing Digital Education Ecosystems, the Digital Education Action Plan (2021–2027) outlines specific measures to promote this ecosystem, including the dissemination of the AI & Data Ethics Guidelines for Teaching and Learning to educators, school leaders, and other stakeholders.

At the same time, the EU's High-Level Expert Group on AI and Data in Education and Training has noted that "the Ethics Guidelines for the use of AI and data in teaching and learning represent an ongoing process of reflection and learning" [6]. Accordingly, when evaluating any AI system, it is essential that the institution – whether a school, college, or university – and its teaching staff are empowered to pose the right questions and to engage in constructive dialogue with AI providers or relevant regulatory authorities.

These guiding questions are embedded within the *Ethical Considerations and Requirements underpinning the EU Ethics Guidelines*. They reflect the core requirements for trustworthy AI systems and serve to structure an ethical dialogue about their use in teaching and learning. Some questions focus on practical implementation, while others address foundational ethical concerns:

1. Requirement is *human-centeredness and control of the AI system*, for which the following questions should be answered:

- Is the teacher's role clearly defined to ensure their involvement whenever the AI system is in use?
- How does the AI system affect the teacher's didactic role?
- Are decisions impacting learners made with teacher participation, and can teachers detect anomalies or potential bias?
- Are there clear procedures enabling teachers to monitor the system and intervene, for example, in situations that demand empathy when interacting with students or parents?
- Is there a mechanism allowing learners to opt out of AI-driven instruction if their concerns are not adequately addressed?
- Are monitoring controls in place to prevent overreliance on or blind trust in the AI system?
- Do teachers and school leaders have the training and information necessary to use the AI system effectively, safely, and in full respect of learners' rights?

2. Requirements are *the transparency* of the AI system, for which it is necessary to answer the following questions:

- Are teachers and school leaders aware of the AI methods and functionalities employed by the system?
- Is it clear which tasks the AI system can and cannot perform?
- Do educators understand how specific assessment or personalization algorithms operate?
- Are system processes and outputs aligned with intended learning outcomes?
- How reliable are the system's predictions, assessments, and classifications in terms of justifying its ongoing use?

- Are user instructions and explanatory materials accessible and comprehensible to both teachers and learners?

3. Requirements: *Diversity, Non-Discrimination, and Fairness*:

- Is the AI system equally accessible to all users without barriers?
- Does it offer appropriate interaction modes for learners with disabilities or special educational needs?
- Has the system been designed to respect learners by adapting to their individual requirements?
- Is the user interface age-appropriate and user-friendly?
- Has usability testing been conducted with the target age group to validate the user experience?
- Are there procedures to ensure the AI's use does not lead to discrimination or unfair treatment?
- Do the system's documentation and training processes clarify potential data biases?
- Are there mechanisms to detect and mitigate bias or unintended inequities?

4. Requirements: *Social and Environmental Well-Being*:

- How does the AI system affect the social and emotional well-being of learners and educators?
- Does the system clearly signal that its social interactions are simulated, lacking genuine feelings or empathy?
- Are students and their guardians involved in decisions about deploying and supporting the AI system?
- Are data used to help educators and administrators monitor learner well-being, and if so, how is this tracked?
- Does the use of the AI system cause any harm or distress to individuals or society at large?

5. Requirements: *confidentiality and data management*:

- Are there mechanisms to anonymize sensitive data?
- Are procedures in place to restrict data access to authorized personnel only?
- Is learner data stored securely and used solely for its intended educational purposes?

• Can teachers and administrators flag privacy or data-protection concerns?

• Are learners and staff informed about how their data is processed and for what purposes?

• Are privacy and data-protection settings configurable by users?

• Does the system comply with the General Data Protection Regulation (GDPR)?

6. Requirements: *technical reliability and security*:

• Is the system secured against data breaches and unauthorized access?

• Is there a monitoring and verification strategy to ensure the AI system meets its objectives and stays within its defined scope?

• Are oversight mechanisms in place for data collection, storage, processing, minimization, and usage?

• Is technical documentation available to reassure learners and parents of the AI system's reliability and safety?

7. Requirement: *accountability*:

• Who is responsible for the continuous monitoring of the AI system's outcomes, and how are those outcomes used to improve teaching, learning, and assessment?

• How is the system's effectiveness and impact evaluated, and how are core educational values incorporated into that evaluation?

• Who holds ultimate responsibility for procurement and deployment decisions regarding the AI system?

• Is there a clear service-level agreement defining support, maintenance services, and escalation procedures for reported issues? [summarized from: 6]

Depending on the goals, AI and data can be useful in various ways:

– Selecting appropriate resources and planning lessons or courses;

– Adopting adaptive learning technologies tailored to each learner's abilities;

– Using student dashboards to guide learners through their educational journey;

– Providing personalized interventions for special needs;

– Automating essay grading via AI-driven tools;
– Forecasting potential student dropout;
– Managing student recruitment and resource planning;
– Using chatbots for consulting students and parents in administrative tasks.

Considering the possibilities of using AI and data in education and training, the EU emphasizes that the school/educational institution must prepare and implement a joint and reflective process of internal self-assessment. This requires teachers to examine how they can use AI systems to positively support the teaching and learning of students, as predicting the consequences and impact of using data and AI in education can be very challenging. Therefore, a gradual approach to the development and implementation of these technologies and their evaluation is necessary. The idea is to gradually introduce these tools into their context and continuously monitor the societal consequences that may arise, leaving open the possibility to retreat when unforeseen consequences occur. The ethical application of AI in education requires the involvement of the student, the teacher, school leadership, and the institutional level.

Effective planning for the use of AI and data in schools/educational institutions in the European Union involves the following steps:

1. *Planning the effective use of AI and data in the school*. For this, it is useful to list the data that the school collects and clarify what purpose it serves. Schools should consider whether there is less specific information that could be gathered to achieve the same outcome. They should also consider how long the data will be needed and how the school can store it for as little time as possible.

2. *Initiation of policies and procedures*. Before implementing the AI system, it is necessary to establish a school-wide policy and procedures to define expectations and provide guidance on how to consistently address issues as they arise. These may include measures for:

– Procurement of trustworthy, human-centred AI;
– Human oversight mechanisms;

– Ensuring input data aligns with the AI system's intended purpose;
– Training requirements for staff;
– Ongoing monitoring and corrective actions;
– Compliance with GDPR obligations, including conducting Data Protection Impact Assessments.

3. *Conducting a pilot test of the AI system*. It is useful to test the AI system on a specific group of students. It is important to have a clear understanding of what the school aims to achieve with the new technology so that a reasoned decision can be made with the involvement of students and their parents. Specific evaluation criteria are needed to make a reasoned judgment about the effectiveness of the AI system in terms of improving learning outcomes, cost-effectiveness, and ethical use.

4. *Collaboration with the AI system provider*. It is important to maintain contact with the AI system provider before deployment and throughout the entire life cycle of the AI system. Look for clear technical documentation and seek clarification on any unclear aspects. An agreement on the service level (SLA) should be established with the provider, which outlines the support and maintenance services, as well as the steps that need to be taken to address reported issues. Guarantees should be obtained from the provider regarding compliance with applicable legal obligations.

5. *Monitoring the operation of AI systems and assessing risks*. The use of AI systems should be continually monitored to evaluate their impact on teaching, learning, and assessment methods. At the school level, it will be important to decide how monitoring will be organized and conducted, who will be responsible for monitoring, and how progress will be determined and reported. Evidence gathered from continuous monitoring should inform and influence the future use of AI systems or the decision not to use them under certain circumstances [summarized from: 6].

Planning for the effective use of AI and data in schools/educational institutions in the European Union is recommended to be accompanied

by *planning for community awareness and engagement, which involves the following steps*:

1. *Discussion with colleagues*. Encourage cross-staff discussions to share insights and delegate tasks, fostering collective effectiveness.

2. *Collaboration with other schools*. This is an effective way to exchange experiences and best practices, as well as to learn how other schools implement AI systems. It is also useful for identifying reliable AI and data system providers that meet key requirements for reliable AI. It is important for schools to participate in controlled projects and experiments organized at regional, national, or European levels through initiatives such as Erasmus+.

3. *Communication with parents, students, and the school community*. Involving parents and students in discussions and decision-making leads to better understanding and trust in what the school aims to achieve through AI systems. It is essential to carefully consider how to explain what data is being collected, what is being done with it, how and why it is collected, and how it is protected.

4. *Be aware of developments*. As AI systems continue to evolve and the use of data increases, it is very important to develop a better understanding of their impact on the surrounding world, including education and training. Educators will need to continue to stay informed about innovations and developments through participation in continuous professional learning and engagement in collaborative practices. School leaders will need to provide opportunities for staff to upskill and continue to develop competence for the ethical use of AI and data. [summarized from: 6].

The *Ethical Guidelines for the Use of AI and Data in Teaching and Learning for Educators* outline new competencies for the ethical use of AI and data. Their relevance is justified by the fact that educators and school/educational institution leaders play a central role in the successful implementation of AI systems and in realizing the potential benefits of digital data in the education sector in the European Union. Therefore, it is important for educators and school leaders to understand and appreciate the opportunities and challenges of using AI systems and how they can enhance teaching, learning, and assessment practices.

This will give rise to new digital competences, which should be considered within the context of the European Framework for the Digital Competence of Educators (DigCompEdu). DigCompEdu provides a common reference framework to support the development of specific digital competences for educators across Europe [7]. Its structure is designed for teachers at all educational levels–from early childhood to higher and adult education, including general, vocational, special, and informal learning. The framework aims to establish a shared coordinate system for all stakeholders who design digital-competence models: EU Member States, regional authorities, national and regional agencies, educational organizations, and public or private professional-training providers in the European Union.

Below are the potential indicators of new competences for educators and school leaders in the ethical application of AI and data in teaching and learning in the European Union (Table 3).

Thus, the challenges and risks of the ethical use of AI and data in teaching and education lie in the need for ethical education, where educators must be specifically trained to understand the ethical aspects of AI use. The lack of such training can lead to unethical use of these technologies.

In 2016, the European Commission launched the *New Skills Agenda for Europe* [8]. Within this initiative, recommendations were developed for member states to implement the program *Upskilling Pathways: New Opportunities for Adults*,' aimed at improving the basic skills of the population in the areas of literacy, mathematics, and digital competence.

Additionally, the Commission issued a *Recommendation on Key Competences for Lifelong Learning*, with a particular emphasis on developing skills in STEM (science, technology, engineering, and mathematics), digital literacy, entrepreneurial thinking, and creativity.

To foster digital skills and competences among all EU citizens, *the Digital Education Action Plan* was adopted. A key component of this Plan is the examination of artificial intelligence's impact on education and learning processes, carried out through targeted pilot projects.

Table 3

Potential Indicators of New Competences for Educators and School Leaders in the Ethical Use of AI and Data in Teaching and Learning in the EU

Element of competence	Potential Indicator
1	2
Sphere 1: Professional engagement – the use of digital technologies for communication, collaboration, and professional development.	
Able to critically describe	– Actively participates in continuous professional development in AI and learning analytics, and their ethical use.
	– Able to provide examples of AI systems and describe their relevance.
Positive and negative impact of AI and data use in education	– Knows how the ethical impact of AI systems is assessed in schools.
	– Knows how to initiate and promote strategies in the school and its wider community that encourage the ethical and responsible use of AI and data.
	– Understands how to initiate and advance strategies within the school and its wider community to promote the ethical and responsible use of AI and data.
Understands the basics of AI and analytics study	– Aware that AI algorithms operate in ways that are not typically visible or easily understandable to end users.
	– Capable of interacting with AI systems and providing feedback to influence their subsequent recommendations.
	– Recognizes that sensors embedded in many digital technologies and applications generate large volumes of data, including personal data, which can be used to train AI systems.
	– Familiar with the EU's ethical principles on AI and with available self-assessment tools.

Continuation of Table 3

1	2
Sphere 2: Digital resources – searching, creating, and sharing digital resources	
Data Management	– Knows the various types of personal data used in education and training.
	– Understands the obligations to ensure data security and confidentiality.
	– Knows that the processing of personal data is governed by national laws and EU regulations, including the GDPR.
Data Management	– Knows that in compulsory education, personal data processing generally cannot rely on user consent.
	– Knows who has access to student data, how access is controlled, and how long the data is retained.
	– Knows that all EU citizens have the right not to be subject to automated decision-making.
	– Can cite examples of confidential data, including biometric data.
	– Can weigh the benefits and risks before permitting third parties to process personal data, especially when using AI systems.
AI Management	– Understands that AI systems are subject to both national and EU regulations.
	– Can explain the risk-based approach as defined in the EU AI Act.
	– Knows high-risk use cases of AI in education and the corresponding requirements according to the AI Act.
	– Knows how to integrate AI-edited or AI-processed digital content into their own practice and how to evaluate it.
	– Able to explain the key principles of data quality in AI systems.

Continuation of Table 3

1	2
Sphere 3: Teaching and Learning – management and organization of the use of digital technologies in teaching and learning	
Learning models	– Knows that AI systems implement the designer's understanding of what learning is and how it can be measured; can explain the key pedagogical assumptions underlying this digital learning system.
Objectives of education	– Knows how this digital system addresses various social goals of education (qualification, socialization, subjectivization).
Human agency	– Can assess the impact of an AI system on teacher autonomy, professional development, and educational innovation.
	– Examines sources of unacceptable bias in the data used in AI systems.
Fairness	– Considers the risks associated with emotional dependency and students' self-esteem when using interactive AI systems and learning analytics.
Humanity	– Can take into account the impact of the use of AI and data on the student community.
	– Confidently engages in discussions on the ethical dimensions of AI and their implications for technology use.
Participates in the development of educational practices that use AI.	– Can explain how ethical principles and values are incorporated and negotiated during the co-design and collaborative development of AI- and data-driven learning practices (in the context of instructional design).
Sphere 4: Assessment – the use of digital technologies and strategies to improve assessment	
Personal differences	– The realization that students respond differently to automated feedback.
Algorithmic bias	– Considers the sources of unacceptable bias in AI systems and ways to mitigate it.

Continuation of Table 3

1	2
Cognitive focus	– Recognizes that AI systems assess a student's progress based on predefined subject knowledge models.
	– Recognizes that most AI systems do not assess collaboration, social skills, or creativity.
New ways of abusing technology	– Knows common methods of manipulating AI-based assessments.
Sphere 5: Expanding student capabilities – using digital technologies to improve inclusion, personalization, and active student participation	
AI meets the diverse educational needs of students.	– Knows how personalized learning systems can adapt their behaviour (content, learning pathways, pedagogical approach).
	– Can explain how the system can benefit all learners regardless of their cognitive, cultural, socioeconomic, or physical differences.
	– Recognizes that digital learning systems may treat different student groups in different ways.
	– Can evaluate the impact on a student's self-efficacy, self-assessment, thinking, and cognitive and emotional self-regulation.
Justified choice	– Knows that AI and data use may advantage some learners more than others.
	– Can explain which evidence underpinned the decision to deploy this AI system in class.
	– Acknowledges the need for ongoing monitoring of AI outcomes and can learn from unexpected results.
Sphere 6: Promoting students' digital competence – providing students with the opportunity to creatively and responsibly use digital technologies for information, communication, content creation, well-being, and problem-solving.	
AI and the ethics of learning analytics	– Able to use AI projects and deployments to help students learn about AI ethics and the use of data in education and training.

Source: summarized by the author based on [6]

The current *European Skills Agenda* is a five-year plan designed to help individuals and businesses develop and leverage more and better skills by:

– Strengthening sustainable competitiveness;
– Ensuring social fairness;
– Building resilience [8].

The European Commission is adopting a new, dynamic EU-level skills policy approach aimed at guiding Member States and supporting the twin green and digital transitions, as well as ensuring recovery from the socio-economic impact of the COVID-19 pandemic. To succeed, lifelong learning for all must become a reality across Europe – in every Member State and region. The Recovery Plan for Europe, proposed by the Commission in May 2020 for the period 2021–2027, likewise focuses in part on measures related to skills, innovation, and digital technologies [10].

The European Skills Agenda defines targets to be met by 2025, based on quantitative indicators (Table 4).

Table 4

EU Skills Targets to Be Achieved by 2025

Naming of indicators	Goals for 2025	Current level (available last year)	Increase in percentage
Participation of adults aged 25–64 in learning over the last 12 months (%)	50 %	39.5 % (2022)	+27 %
Participation of low-skilled adults aged 25–64 in training over the last 12 months (%)	30 %	18.4 % (2022)	+63 %
The share of unemployed adults aged 25–64 with recent learning experience (%)	20 %	14.1 % (2023)	+42 %
The share of unemployed adults aged 25–64 with recent learning experience (%)	70%	55.6 % (2023)	+26%

Source: [8]

First of all, the European Commission considers it necessary to significantly increase the share of adults participating in education overall – only this guarantees an approach to lifelong learning. In addition, to ensure that recovery and the dual transition are socially fair, the Commission also proposes clear targets for the participation of low-skilled adults and the unemployed in education.

By 2025, 120 million adults in the EU should participate in learning each year. This corresponds to 50 percent of the adult population and approximately 540 million learning activities for this group over the five-year period. By 2025, 14 million low-qualified adults should engage in learning annually, equivalent to 30 percent of that cohort and roughly 60 million learning activities over five years. Monitoring this indicator alongside the actions set out in the European Skills Agenda for Sustainable Competitiveness, Social Fairness, and Resilience will also help reduce the share of low-qualified adults, which stood at 22 percent in 2019 – a figure that lags behind many global competitors.

Furthermore, by 2025, 2 million job seekers – approximately one in five – should have recent learning experience, equating to some 40 million learning activities for this group over five years. Regarding learning content, a broad spectrum of skills will be needed to support recovery and the success of the Twin Green and Digital Transitions. In particular, digital skills, strengthened by the COVID-19 context, are essential for work, education, and social interaction. Therefore, the fourth monitoring target is the share of adults who possess at least basic digital skills. By 2025, 230 million adults – 70 per cent of the EU's adult population – should have at least a basic level of digital competence [summarised from: 9].

To achieve its skills targets, the European Union is making substantial investments. Beyond contributions from businesses and Member State governments, the EU budget now prioritises investment in people and their skills (Table 5).

It is estimated that meeting the overall adult-learning participation goal will require an additional €48 billion per year. Moreover, rolling

out the full Skills Agenda will necessitate further funding to support activities at the EU, national, regional, and local levels.

Table 5

EU Budget Priorities for Skills Investments

Program	Investment (€ billion)
Recovery and Resilience Facility (RRF)	67.7
European Social Fund Plus (ESF+)	42
Erasmus+	26.1
European Regional Development Fund (ERDF), incl. Interreg	8.7
InvestEU	2.8
Just Transition Fund (JTF)	3.1
European Globalisation Adjustment Fund	1.1
Asylum, Migration and Integration Fund (AMIF)	0.8
European Solidarity Corps	0.8
Digital Europe	0.5
Technical Support Instrument (TSI)	0.024
EU4Health	0.016
Total	153.64

Source: [8]

The EU budget in the field of skills is closely integrated with *Next Generation EU (NGEU)* – a temporary instrument for economic recovery established by the European Union in 2020 to tackle the economic and social consequences of the COVID-19 pandemic. *The main goal of NGEU* is to assist EU member states in overcoming the economic and social impacts of the COVID-19 pandemic, making their economies more resilient, environmentally friendly, and digital, as well as promoting inclusive growth.

The Commission's proposal for Next Generation EU (NGEU) includes significant resources within a large-scale budget initiative to address the economic and social consequences of the crisis. The

Commission will ensure the effective use of its tools to support and unlock investments in human capital, promoting gender equality and inclusiveness. Member states will be invited to use EU financial resources *to implement national reskilling and upskilling schemes for the workforce*.

In the short term, REACT-EU, financed under *NextGeneration EU* and the proposed adjusted 2020 EU budget, will provide €55 billion to the Cohesion Policy funds for 2020–2022. This allocation enables the European Social Fund to channel additional financing into upskilling *opportunities that accompany the green and digital transitions*.

Moreover, the *Recovery and Resilience Facility*, totalling €560 billion in grants and loans, offers Member States extensive scope to fund upskilling and reskilling measures. The European Commission's 2020 country-specific recommendations focused on urgent actions to mitigate the socio-economic impact of the pandemic, identifying *skills, education, and vocational training as a short-term priority for 22 Member States*. The national recovery and resilience plans that countries must submit to access Facility financing are required to reflect skills development as a programming priority.

During the 2021–2027 period, the *European Social Fund Plus (ESF+)*, with a proposed budget of €86 billion, will remain a key source of *financing for national upskilling and reskilling initiatives*.

In addition, the proposed €24.6 billion for *Erasmus+ will support skills development and fund several of the measures mentioned above*, such as European Universities, Centres of Vocational Excellence, and Sectoral Skills Alliances. Moreover, Erasmus+ can facilitate a significant expansion of *both physical and virtual learning mobility across the EU*, opening up new educational opportunities that may not be available domestically.

The *Horizon Europe programme* will play a pivotal role in the recovery, particularly in driving the twin green and digital transitions, by supporting industry and SMEs, as well *as universities and researchers, and by fostering brain circulation and researcher mobility*. The new Digital Europe programme will invest in the

enhancement of academic offerings in digital fields and in specialised training opportunities in areas such as *data processing, cybersecurity, and artificial intelligence*, thereby addressing the current skills shortage in these critical sectors.

Other resources can directly support the *upskilling and reskilling of Europe's workforce*. Member State investments in "socially impactful infrastructure" for education and training, including digital infrastructure, can be further backed by the *European Regional Development Fund and the InvestEU programme*. Under its "Social Investment and Skills" window (with a proposed budget guarantee of €3.6 billion), Invest EU can, among other things, fund investments in *critical education and training infrastructure*.

In the context of the green transition, the Commission has made "*just transition skills*" a priority for all *27 Member States*, utilising the Just Transition Fund with its proposed €40 billion envelope. The public-sector loan facility under the Just Transition Mechanism – expected to mobilise €25–30 billion – can also invest in skills. The ceiling of the European Globalisation Adjustment Fund has been proposed for doubling in the next Multiannual Financial Framework to support upskilling and reskilling of workers and self-employed persons made redundant by large-scale industrial restructuring. Other instruments, such as the Modernisation Fund, will likewise finance upskilling and reskilling programmes to assist workers in regions and sectors affected by the green transition. [summarised from: 9].

The implementation of the Skills Agenda – including the Pact for Skills and the use of NextGenerationEU resources – encompasses a wide range of actions, for example:

– *Investments in inter-company training centres*, where firms along a value chain pool resources to deliver specialised staff training;

– *Full-scale deployment of enhanced Sectoral Skills Alliances* at national and regional levels;

– *Development and operation of skills-forecasting systems* that provide actionable intelligence on upskilling and reskilling needs at national, regional and sectoral levels – explicitly covering both the

green and digital transitions – and encompassing all stages of data collection, analysis and dissemination;

– *Design and roll-out of National Skills Strategies*, developed and implemented through a cross-government approach to accompany the twin transitions, aligning efforts across a broad policy spectrum with the active involvement of stakeholders (social partners, civil society, labour-market actors, and education and training providers);

– *Reforms of vocational education and training (VET) and apprenticeship programmes*, including curriculum modernization to better match labour-market needs, integration of green and digital skills, enhanced flexibility and modularity, expansion of higher VET pathways, establishment of quality-assurance and graduate-tracking systems, up-skilling of VET teachers and trainers, support for learner, teacher and trainer mobility, and creation of Centres of Vocational Excellence linked to smart-specialisation or regional innovation and growth strategies;

– *Direct apprenticeships subsidies for SMEs*, covering trainee remuneration, hiring bonuses and temporary social-security contributions (up to 12 months), as well as instructors' salaries and social contributions, to stabilise and expand high-quality apprenticeship offers;

– *Investments in digital learning equipment and technologies*, and in advanced industrial machinery and technologies for education and training providers;

– *Incentives for the development of digital learning content and core curriculum modules* tailored to labour market needs, with a focus on digital and green skills, including online learning platforms;

– *Short-term reskilling courses* for workers transitioning to new job roles and skill requirements arising from the green and digital transitions – e.g., ICT Jump-Start and Digital Crash courses targeting SMEs to deliver intensive, rapid upskilling in ICT;

– *Master's-level programmes* to train digital experts in advanced digital competences required for digital transformation, and to prepare specialists with green-economy skills;

– *Regional and local entrepreneurial-skills hubs* supporting start-ups, employee-entrepreneurs, and innovators;

– *Investments in the quality, equity, and labour-market relevance of education and training systems* to ensure individuals acquire the key competences needed in today's workplaces and societies;

– *Support for community learning centres for adults*, where people of all ages engage in learning and knowledge exchange, fostering resilient, cohesive communities;

– *Creation, pilot implementation and operation of individual learning account schemes*;

– *Measures to encourage and facilitate learning participation*, such as adult learning credits/grants, funding for learning leave, and targeted learning support for the unemployed;

– *Support for learning initiatives accompanying reduced-working-time arrangements*, safeguarding workers and self-employed persons, especially against the risk of unemployment [summarised from: 8–9].

The European Commission will work closely with national authorities and other stakeholders to ensure adequate EU resources are allocated to support the various dimensions of the Skills Agenda. The Commission will encourage and assist Member States in prioritising skills investments under the Recovery and Resilience Facility and will monitor progress through the European Semester. This monitoring will be published in the annual Joint Employment Report and will serve as an analytical basis for more targeted country-specific recommendations on skills, education, and vocational training. Where feasible, the Commission will track achievements by gender, geographic region, and vulnerable groups, beyond low-skilled and unemployed persons, to include, for example, people with disabilities.

Delivering the Skills Agenda, particularly in digital competences and the application of AI in teaching and learning, opens new horizons for educational practice and plays a pivotal role in developing the knowledge economy, fostering its growth and qualitative transformation.

Nonetheless, *AI uptake among EU enterprises* with ten or more employees remains low: in 2023, only 8.0 % of such firms reported

using any AI technologies, up marginally from 7.6 % in 2021. Considerable disparities exist across Member States. In 2023, the top ten countries exceeded 10 % AI adoption in non-financial enterprises (10+ employees): Denmark (15.2 %), Finland (15.1 %), Luxembourg (14.4 %), Belgium (13.8 %), the Netherlands (13.4 %), Malta (13.2 %), Germany (11.6 %), Slovenia (11.4 %), Austria (10.8 %), and Sweden (10.4 %). A second group ranged from 9.2 % to 5.2 %: Spain (9.2 %), Ireland (8.0 %), Croatia (7.9 %), Portugal (7.9 %), Slovakia (7.0 %), the Czech Republic (5.9 %), and Estonia (5.2 %). In the remaining Member States, adoption rates were 5 percent or lower: Italy (5.0 %), Lithuania (4.9 %), Cyprus (4.7 %), Latvia (4.5 %), Greece (4.0 %), Hungary (3.7 %), Poland (3.7 %), Bulgaria (3.6 %), and Romania (1.5 %) [11].

The use of AI and data within the knowledge economy is a critical driver of its development and transformation. A knowledge economy – grounded in the creation, dissemination, and application of information and c – derives substantial momentum from AI's capacity to process, analyse, and interpret large datasets, as well as to automate cognitive tasks.

Specifically, *the application of AI and data in the knowledge economy*:

- *Enhances the quality of human capital*. Personalised learning enabled by AI and data analytics better addresses each learner's needs and abilities. This leads to deeper mastery of content, development of essential skills, and the creation of a more qualified and competent workforce – the very foundation of a knowledge economy.
- *Improves knowledge management*. AI systems can organise, classify, and retrieve information, streamlining access to relevant knowledge for employees and facilitating experience exchange.
- *Generates new knowledge and innovation*. By detecting patterns and trends invisible to human analysts, AI fosters scientific discovery and the development of novel technologies, products, and services.
- *Stimulates innovation*. AI can identify gaps in existing knowledge and priority research areas, thereby catalysing the generation of new

ideas and technologies. Optimized learning processes then prepare specialists capable of innovative thinking and value creation in the knowledge economy.

• *Creates knowledge-based products and services*. AI underpins the development of intelligent information and expert systems, customer-support platforms, and personalized recommendation engines – high-value offerings in the knowledge economy.

• *Increases the efficiency of educational institutions*. By automating routine tasks for educators and administrators, AI frees up time for strategic activities. Data analytics likewise supports curriculum optimisation and resource allocation, boosting overall system performance.

• *Fosters lifelong learning*. AI can craft personalized learning pathways and recommend relevant resources throughout an individual's lifetime. In a rapidly evolving knowledge economy, the ability to continuously update skills and knowledge is essential for maintaining competitiveness.

• *Develops future-oriented skills*. AI and data analytics help anticipate the competencies most in demand in tomorrow's knowledge economy. Customised educational programmes that reflect these insights equip graduates for successful careers in high-tech sectors.

• *Optimises and automates R&D processes*. AI can handle repetitive tasks, analyse vast volumes of experimental data, uncover novel connections and patterns, and thus accelerate scientific breakthroughs and the knowledge-creation cycle. This boosts productivity and liberates human talent for more creative and complex work.

In summary, deploying AI and data in education is not merely a tool for improving instructional processes; it is a strategic catalyst for the knowledge economy, shaping a highly skilled workforce, driving innovation, and enhancing the efficiency of education and research.

Conclusions: The European Union demonstrates a proactive, multifaceted approach to integrating AI and data into education and the knowledge economy. Grounded in principles of ethics, safety, and

human-centrism, the EU is establishing a robust legislative framework, investing in research and innovation, and rolling out concrete programmes to unlock AI's potential. Analysing these European experiences is highly valuable for Ukraine as it seeks to integrate into the European educational and economic space and develop its own capacity in these critical fields.

A key element of the European approach to AI and data in education and the knowledge economy is the creation of an enabling ecosystem. This ecosystem encompasses investments in R&D, support for innovative start-ups, the establishment of competence centres, and the promotion of interdisciplinary collaboration among academia, industry, and the public sector.

Ukraine could draw on European best practice in several ways:

- *Regulatory framework*: Studying the EU AI Act and related regulations can guide Ukraine in crafting its own legal regime for AI in education, balancing innovation with rights protection.
- *Strategic implementation*: European digital skills and AI-in-education strategies can serve as a roadmap for Ukraine's national programmes and initiatives.
- *Research and mobility*: Participation of Ukrainian universities, research centres, and EdTech firms in Horizon Europe and Erasmus+ will facilitate knowledge exchange, attract funding, and accelerate the adoption of cutting-edge European solutions.
- *EdTech adoption*: Adapting proven European AI applications – such as intelligent learning platforms, automated assessment tools, and student-support systems – can help modernise Ukraine's education system and improve learning outcomes.

Ukraine can leverage this experience by fostering public–private partnerships and directing investments toward priority AI research areas with high potential in the knowledge economy, such as natural language processing, machine learning for big-data analytics, and intelligent decision-support systems.

A cornerstone of the European strategy is *its focus on the ethical and legal dimensions of AI use*. EU regulations designed to ensure

algorithmic transparency, accountability, and fairness, alongside the protection of personal data and human rights, are critical to building societal trust in AI and data technologies. In adopting European best practices, Ukraine should develop its own legal framework that both stimulates innovation and minimises the potential risks associated with AI and data use. Incorporating the EU's ethical guidelines for AI in education will be essential for earning the trust of Ukrainian teachers, learners, and parents.

In this spirit, the Ministry of Digital Transformation and the Ministry of Education and Science of Ukraine – working with the relevant Task Force and in accordance with the EU Artificial Intelligence Regulation, adopted by the European Parliament in March 2024 – have prepared the *Guidelines and Methodological Recommendations for the Introduction and Use of Artificial Intelligence Technologies in General Secondary Education Institutions (Draft)*. These guidelines are intended to establish principles for the responsible, ethical, and effective deployment of AI technologies in Ukrainian schools [12].

The document comprises the following components: "AI application domains; core principles for the responsible use of AI systems in general secondary education; organisational deployment of AI in educational institutions; professional development for teachers' AI competence; teachers' use of AI for lesson planning and delivery; typology of AI systems in education" [12]. The Guidelines also include annexes with:

– Sample provisions that can be incorporated into policies, regulations, or recommendations for the responsible use of AI;
– Risk-mitigation measures for AI deployment in education;
– Recommended student activities, with age-appropriate restrictions for AI-based services;
– Levels of AI tool integration for completing learning tasks;
– The digital-competence framework for teaching and research staff, enhanced with AI-related components;
– Guidance on prompt engineering, including sample prompts;
– Ideas for using AI tools during classroom instruction;
– Examples of generative AI tools for education [12].

In the context of the knowledge economy, European experience highlights AI and data's significant potential to enhance *educational and research processes*. AI systems can personalise learning, automate routine tasks for educators and researchers, analyse large corpora of scientific literature, uncover emerging trends and patterns, and support decision-making in R&D. Introducing these tools into Ukrainian schools, vocational institutions, universities, and research centres could substantially improve the quality of education and research.

Furthermore, AI and data increasingly underpin *innovation in the knowledge economy*. European companies deploy AI to build intelligent information systems, knowledge-management platforms, collaborative knowledge-sharing environments, and new educational and consulting services. Encouraging Ukrainian businesses to adopt similar technologies will foster high-tech job creation and increase the national economy's value added.

In summary, importing European best practices for AI and data in the knowledge economy is strategically vital for Ukraine. This endeavour demands a holistic approach – establishing an enabling ecosystem, developing ethical and legal standards, investing in education and research, and supporting innovative enterprises. By adapting successful European models, Ukraine can fully harness AI's benefits to advance its knowledge economy, enhance competitiveness, and secure a sustainable future.

List of used sources

1. European approach to artificial intelligence. URL: European approach to artificial intelligence | Shaping Europe's digital future. (Last accessed: 18.04.2025).

2. Artificial intelligence. Glossary. An official website of the European Union. URL: https://interoperable-europe.ec.europa.eu/collection/better-legislation-smoother-implementation/glossary/term/artificial-intelligence (Last accessed: 21.04.2025).

3. White Paper on Artificial Intelligence – A European approach to excellence and trust. URL: https://ec.europa.eu/info/sites/default/files/

commissionwhite-paper-artificial-intelligence-feb2020_en.pdf (Last accessed: 25.04.2025).

4. AI Act. URL: AI Act | Shaping Europe's digital future (Last accessed: 18.04.2025).

5. Support ecosystem for AI innovation in Europe. URL: Support ecosystem for AI innovation in Europe | Shaping Europe's digital future (Last accessed: 22.04.2025).

6. Ethical guidelines on the use of artificial intelligence (AI) and data in teaching and learning for educators. URL: Ethical guidelines on the use of artificial intelligence (AI) and data in teaching and learning for educators – Publications Office of the EU (Last accessed: 18.04.2025).

7. Digital Competence Framework for Educators (DigCompEdu). URL: https://joint-research-centre.ec.europa.eu/digcompedu_en (Last accessed: 25.04.2025).

8. European Skills Agenda. URL: European Skills Agenda – European Commission (Last accessed: 23.04.2025).

9. European Skills Agenda For Sustainable Competitiveness, Social Fairness And Resilience. URL: https://ec.europa.eu/social/BlobServlet?docId=22832&langId=en (Last accessed: 23.04.2025).

10. Recovery plan for Europe. URL: Recovery plan for Europe – European Commission (Last accessed: 18.04.2025).

11. DESI indicators. Artificial Intelligence. URL: https://surl.li/ibgpra (Last accessed: 25.04.2025).

12. Guidelines and Methodological Recommendations for the Introduction and Use of Artificial Intelligence Technologies in General Secondary Education Institutions (Draft). URL: https://docs.google.com/document/d/1_zeaxW02Q99jH4mXJkGLBcsJZGIMQMIuPfZZLUiYnfY/edit?tab=t.0#heading=h.hfw7meduf7x9 (Last accessed: 25.04.2025).

DUBYNINA Svitlana,
Doctor of Philosophy, Senior Lecturer of the Department
finance, banking, insurance and stock market,
Zaporizhia National University,
Zaporizhzhia, Ukraine
ORCID: https://orcid.org/0000-0003-4498-4753

1.2. DIGITALIZATION OF FINANCES OF LOCAL GOVERNMENT OF THE ZAPORIZHIA REGION

Introduction. A state that provides a high standard of living, has the latest technological developments, implements digital finance with transparent and zero corruption at all levels is a leader of a strong digital economy and sustainable development. Therefore, the digitalization of regions and communities is a guarantee of the well-being of the population, the creation of new opportunities, the social transformation of life to the European level into modern, comfortable and safe, the reconstruction of the latest opportunities for the implementation of working capital, the development of innovative, creative and digital technologies and business, that is, the creation of a better life, work, creativity and education. The digitalization of local government finances in the Zaporizhia region has provided an opportunity to create industrial parks in communities, open new IT enterprises, digitize their services for businesses, conduct a digital campaign among doctors, educators, and municipal employees, connect settlements to fiber – optic networks and provide settlements with 4G mobile communications, implement an integrated video surveillance system, develop an electronic queue for enrolling a child in an institution, and introduce online doctor's appointments in hospitals. All of the above social, economic, and municipal services work thanks to the effective use of digital tools by local governments in the Zaporizhia region and meet modern EU requirements.

Presentation of the main material. Despite the war that has lasted for more than 3 years, Ukraine, creating innovative

products, is becoming the most powerful state and leader with working digitized state and social services. Ukraine has achieved powerful changes in digital transformation and the country's digital economy guarantees a high, comfortable standard of living for its citizens, increased incomes, social support, and the introduction of barrier-free access for vulnerable segments of the population. It should be noted that Ukraine is the only European country that has sufficient human resources that can be used in the development of the digital economy [1]. It is digital tools that today decide and implement the reforms required by the status of a candidate for EU accession – these are the principles of transparency, democracy, openness, and accountability. The Cabinet of Ministers of Ukraine, by its Resolution No. 1351-r dated December 31, 2024, approved "On approval of the Strategy for the Digital Development of Innovative Activity of Ukraine for the period until 2030 and approval of the operational plan of measures for its implementation in 2025–2027". This resolution also approved the operational plan of measures for the implementation in 2025–2027 of the Strategy for the Digital Development of Innovative Activity of Ukraine for the period until 2030 [2]. The strategic digital development of Ukraine provides for the following key goals:

– "priority of developing an innovative ecosystem in educational institutions, creating conditions for in-depth study of academic subjects and integrated courses in mathematical and natural science educational fields";

– "improvement of coordination and interaction in the formation and implementation of policy in the field of innovation activity";

– "regulation of the regulatory framework for innovation, scientific, industrial and technological parks, Industry 4.0 centers, as well as the functioning and support of business accelerators, business incubators and startups";

– "stimulating research and development in conditions of limited material resources, enabling the implementation of innovative projects in priority areas";

– “ensuring the development and implementation of digital innovations in the defense sector”;

– “increasing the efficiency of the agricultural sector and land management through innovative solutions”;

– “ensuring the creation of conditions for the development of internal infrastructure for research, innovation and implementation of solutions in the field of artificial intelligence”, etc.

The approved strategic goal of the digital development of Ukraine stipulates that all regions of Ukraine should join the Smart Platform of European Specialization (S3 PLATFORM) in order to include the regions of Ukraine and give them access to the tools of the European Platform. It also stipulates the development and implementation of processes of state financial support for regional development projects that provide for the sustainable development of types of economic activity that are extremely important for Ukraine, implemented through smart specialization and provided for in regional sustainable development strategies. However, due to the outbreak of the war in the Russian Federation, the inclusion and accession of Ukrainian regions (of Ukraine this European platform) to smart – specialization has been suspended. As of December 2024 to European platform, eleven regions of Ukraine (Volyn region, Dnipropetrovsk region, Zhytomyr region, Chernivtsi region, Sumy region, Mykolaiv region, Kherson region, Zaporizhia region, Autonomous Republic of Crimea, Kyiv city, Sevastopol city) did not join [2]. The “Ministry of Development of Communities, Territories and Infrastructure of Ukraine” together with the “Ministry of Digital Transformation of Ukraine” are developing and agreeing on the “Concept of Digital Solutions for ATC”. This Concept will significantly help to implement state regional policy and implement decentralized reform. The Concept structures and prioritizes the implementation of digital technologies in regions that strengthen reforms. The Concept is a vector that guides donors who invest in digital solutions in Ukraine, and is also a guideline for sustainable development for communities and regions. The formulated directions of the Concept are concentrated and presented in Table. 1 [5].

Table 1

Key areas of the Concept

No.	Name of the direction
1	"The DREAM Single Digital Recovery Management Ecosystem"
2	"A unified geographic information system for monitoring and evaluating the development of regions and territorial communities (GIS of regional development)"
3	"Register of local government decisions"
4	"Urban planning cadastre at the state level"
5	"Digital solutions for local finance administration"
6	"Digital solutions for implementing local democracy"
7	"Register of municipal property"

Source: compiled based on [5]

Digitalization of processes, namely, monitoring, control, audit and administration of financial flows, should increase not only the cash flows of local budgets, but also contribute to the implementation of transparency, monitoring and independence of local government bodies, promote self-synchronization of strategic planning and budgeting, financial planning, and increase profitability by collecting financial resources, namely local taxes and fees. Also, digitalization of local government finances attracts and ensures the active participation of business and the concerned public in the post-war reconstruction and sustainable development of Ukraine, provides local government bodies with a new technological tool for discussing socially important issues with the public, increases the variability of opportunities by conducting surveys and voting among the localities. In addition, digital technologies expand the opportunities of the public to participate in the development and restoration of the country, offering their projects, participating in grants and distributing funding. By implementing digital tools, every citizen feels like a necessary part of society, involving their advice and opinions to improve the country, notifying local authorities about current, urgent problems regarding the improvement of the housing and communal services and infrastructure sectors, etc. The use of digital

technologies improves the objectivity of monitoring, controlling, auditing, and the effectiveness of projects during their implementation. Optimization and improvement of local tax administration, the concept of which is reflected in several state legislative acts, in particular, in the "National Revenue Strategy until 2030" (CMU Order No. 1218-r dated 27.12.23) [7], "Plan of measures for reforming local self-government and territorial organization of power in Ukraine for 2024–2027" (CMU Order No. 270-r dated 26.03.2024) [8], "Budget Declaration for 2025–2027" (CMU Resolution No. 751 dated 28.06.2024) [9]. Several examples of government decisions on the implementation of digital technologies and systems can be given, for example, the "TREMBITA" system, the "PORTAL" DIYA, the "PROZORRO" system, the "SPENDING" system, etc.

To develop innovations in management, the Ministry of Digital Affairs of Ukraine uses and involves everyone in the use of an effective management system – OKR (Performance Measurement System), which is practiced by technology giants Google, Amazon, Microsoft, Intel, Samsung and others. The system provides an increase in the range of services and the implementation of unplanned projects: legal, HR, IT processes, innovative and technological, modernization of government digital technologies, digital education, smart services for citizens and businesses, 4G communications, European integration and international cooperation relations [10].

Zaporizhia region is one of the first to implement digital governance at all levels of administration and the City Council Resolution No. 117 dated February 23, 2022 approved "On Approval of the Concept "Digital Strategy of Zaporizhia-2030" [11]. Local governments of the Zaporizhia region were guided by the following legislative acts:

– The Law of Ukraine "On Local Self-Government in Ukraine";
– The Law of Ukraine "On Information";
– Resolution of the Cabinet of Ministers of Ukraine dated August 5, 2020 No. 695 "State Strategy for Regional Development for 2021–2027", in accordance with the requirements of the section "Digital Transformation of Regions";

– By decision of the Zaporizhia City Council dated December 28, 2020 No. 40, in accordance with the City Target Program "Digital Strategy of the City for 2021–2023" (as amended).

The adoption of the Concept of the Digital Strategy 2030 of the Zaporizhia region will not only ensure the implementation of the principles of digitalization of the state economy, the development of sustainable development of the region, but also increase the range of social digital services and services for the local population of territorial communities.

The concept of the Digital Strategy of the Zaporizhia region is based on important principles such as simplifying citizens' access to various services, the principle of barrier-free access , the use of artificial intelligence in solving urban problems, involving business, the public and scientists in the development of the city, digitalization of document flow in local government bodies and municipal enterprises, increasing security, improving communications between city residents, local authorities and business representatives. These are the main ideas, but, in addition, digitalization allows you to save budget funds, increase the investment attractiveness of the city and strengthen information protection. Zaporizhia local governments face some challenges, but are actively solving them, this concerns the implementation of digitalization in the field of health administration at the community level, despite the fact that all communities have Health Care Institutions "HCI" in their ownership, on the territory of the community, but there are still not enough competencies, tools and data for effective management of these institutions and control over the provision of medical services. Currently, cities are promptly resolving these issues, strengthening competencies and providing access to the necessary information for local government at the community level, and implementing reforms of electronic, municipal medical digital data systems regarding disease statistics. Local governments of the Zaporizhia region actively participate in new competitions, including the European Union program " Digital Europe ". This program with a budget from donors of more than 3.2 billion euros. The funding provides for the implementation of

digital economic projects aimed at the sustainable development of the entire region:

– high-performance computing;
– AI, data and cloud technologies;
– digital skills;
– introduction of digital technologies into the economy, finance and society.

Grants foreseen in 2025 are presented in Table 2.

Table 2

Proposed Grants in 2025

No./ no.	Grant name	Competition description	Submission deadline	Budget, million Euros
1	2	3	4	5
1	Grant "Creating an Academy of Artificial Intelligence Skills"	creation of an educational center with a focus on generative AI, quantum technologies and practical training	2.09.2025	10 million euros
2	Grant "Creating a Skills Academy for Virtual Worlds"	creating educational programs with Web 4.0, metaverses, 3D modeling and simulations	2.09.2025	10 million euros
3	Grant "Creation of the Academy of Quantum Technologies"	developing courses, summer schools, and internships for acquiring quantum skills	2.09.2025	7 million euros
4	Grant "Creating an operational system for responding to disinformation threats"	creation of a European network of fact-checkers and development of tools to combat disinformation	2.09.2025	5 million euros

Continuation of Table 2

1	2	3	4	5
5	Grant “Supporting national initiatives for child safety in the online environment”	supporting a network of Safer Internet Centers in Europe	2.09.2025	42 million euros
6	Grant “Supporting Innovation in Microcircuit Production and Semiconductor Technologies “	support for the activities of the Secretariat of the Alliance for Processors and Semiconductor Technologies (Alliance on Processors and Semiconductor Technologies) to strengthen the European ecosystem in the development and production of microprocessors and semiconductors	2.09.2025	1 million euros
7	Grant “Digitalization of data exchange in agriculture “	creating AI-based tools for the agricultural sector within the European Green Deal	2.09.2025	15 million euros
8	Grant “Development and Coordination of Pan-European Data Spaces “	developing tools for sharing and securely using data	2.09.2025	10 million euros
9	Grant “Development of advanced solutions for real-time data protection and management “	development and implementation of innovative digital solutions in the fields of agriculture, healthcare, energy, ecology and production	2.09.2025	8 million euros

Continuation of Table 2

1	2	3	4	5
10	Grant “Creation and Development of European Digital Innovation Hubs “	expanding the ECIH network, services, particularly in the field of AI, to support the digital transformation of small and medium-sized enterprises (SMEs), government organizations, etc.	05/14/2025	48 million euros
11	Grant “Implementation of educational initiatives in high-performance computing “	development and implementation of a pan-European Master's degree (MSc) in High Performance Computing (HPC), building on the experience of the EUMaster4HPC pilot project	05/14/2025	10 million euros
12	Grant “Development of AI Network of European Digital Innovation Hubs “	strengthening the network of hubs in participating countries with a focus on AI	2.09.2025	9 million euros

Source: Official website of the Ministry of Digital Affairs of Ukraine [13]

Every year, the Ministry of Digital Transformation of Ukraine (Ministry of Digital Transformation) calculates the “Digital Transformation Index” of territorial communities of the regions of Ukraine. The “Digital Transformation Index” is currently one of the technological tools for establishing the level of “digitalization” in the regions of the country. Its analysis of the “Digital Transformation Index” allows not only to find out the effectiveness of the implementation of digitalization by local governments of the regions, but also to

determine the requirements for digital transformation. According to the "Digital Transformation Index", in 2024 the Zaporizhia region took 22nd place out of 24 possible. According to the rating, the leaders are Lviv region – 0.850 points, Dnipropetrovsk region – 0.844 points, and Odessa region – 0.804 points.

The Digital Transformation Index identifies nine key digital indices. Zaporizhia region received the following scores:

- 0.625 points for "institutional capacity" (1 possible);
- 0.462 points for "Internet development";
- 0.249 points for "development of ASCs";
- 0.07 8 points for "implementation of the "paperless" regime;
- 0.552 points for "digital education";
- 0.202 points for "region business card";
- 0.513 points for "penetration of basic electronic services";
- 0.243 points for "industry digital transformation";
- 0.105 points for "individual CDTO projects".

This year's "Digital Transformation Index" includes another new index – "individual CDTO projects". This index allows the CDTO of the Region's administration to independently prioritize activities for digitization according to the needs of the region.

In addition, in 2023, the digital transformation index in the Zaporizhia region was 0.289 points out of 1. And in Ukraine as a whole – 0.632 [12].

Despite the challenges, the Zaporizhia region is actively participating in the digitalization of all areas of management and moving towards digital transformation, and education is one of the key areas. In particular, 10 digital educational centers were opened in the region during 2024. Children can study and develop their skills in them.

Conclusions. In the current conditions – Martial Law, and later – in the post-war recovery period, local governments of Ukraine have major obstacles to economic development – the exit from the markets of investment activity of economic donors and investors. Especially, starting from February 2022, with the beginning of the full-scale military invasion of the Russian Federation into the territory of

Ukraine, this has been sensitively reflected in the inability of regions to attract funds and their usual management, organize the budgeting process, adapt social and economic regional infrastructure in order to carry out certain works. Changes in tax revenues taking into account the reality in the economic sector of the regions and the challenges that required communities to allocate more funds to strengthen territorial defense, assist the Armed Forces of Ukraine, strengthen the defense capability of territories, and provide humanitarian assistance to the civilian population along with current expenditure items.

This has significantly caused difficulties and reduced the ability of territorial communities to direct funds to municipal, social, and cultural development, projects related to communal and infrastructure issues. However, the Zaporizhia region has made decisions on directions aimed at digitalizing all areas of management and is moving towards the digital transformation of territorial communities and local authorities [6].

Zaporizhia region, despite its proximity to the combat zone, about 25 km, and significant destruction of the utility fund, energy and transport infrastructure, cares about humanitarian assistance to its population and directs funds to education, reconstruction, medical, social, environmental reforms, support for veterans and cultural development of the region. And thanks to effective digital technologies and administrative solutions involving all existing, possible resources, their productive classification, distribution and economical targeted use of funds, it continues to compete in the Digitalization rating, also with regions that are in the rear.

Territorial communities of the Zaporizhia region, with low income – a small population and territory, do not have the opportunity and funds to implement digitalization for a comfortable, modern environment, in providing relevant social services to their residents, and this, of course, limits the population in service and reduces the effectiveness of local development and quality management. Despite all the challenges of war and destruction, the city government of the Zaporizhia region continues the digital administration of all territorial communities.

List of used sources

1. Cherep O. G., Shcheblykina I. O., Gul Ya. Digitalization of Ukraine in the post-war period and its impact on jobs. *Financial strategies for innovative economic development*. 2025. Issue 1 (65). P. 109–115. DOI: https://doi.org/10.26661/2414-0287-2025-1-65-18.

2. On approval of the Strategy for the Digital Development of Innovative Activity of Ukraine for the period until 2030 and approval of the operational plan of measures for its implementation in 2025–2027: Order of the Cabinet of Ministers of Ukraine dated 12/31/2024 No. 1351-p URL: https://zakon.rada.gov.ua/laws/show/1351-2024-%D1%80#Text (Last accessed: 30.04.2025).

3. "The idea is to infect state institutions with the "right" virus." The Ministry of Digital Economy uses the OKR method for greater efficiency. How does this help save time and implement AI? URL: https://forbes.ua/innovations/ideya-zaraziti-derzhavni-institutsii-pravilnim-virusom-mintsifri-vikoristovue-metod-okr-dlya-bilshoi-efektivnosti-roboti-yak-tse-dopomagae-ekonomiti-chas-ta-vprovadzhuvati-shi-26112024-25063 (Last accessed: 30.04.2025).

4. On approval of the Strategy for the Development of the Sphere of Innovation Activity for the Period Until 2030: Order of the Cabinet of Ministers of July 10, 2019 No. 526-p. URL: https://zakon.rada.gov.ua/laws/show/526-2019-%D1%80#n12 (Last accessed: 30.04.2025).

5. Official website of the All-Ukrainian Association of ATC. URL: https://hromady.org/cifrova-transformaciya-gromad-instrumenti-ta-rishennya/ (Last accessed: 30.04.2025).

6. Assessment of the financial capacity of territorial communities by the end of 2024. *Ukrainian Institute of International Policy (UIIP)*. URL: https://uiip.org.ua/uk/novyny/otsinka-finansovoi-spromozhnosti-terytorialnykh-hromad-za-pidsumkamy-2024-roku (Last accessed: 30.04.2025).

7. On approval of the National Revenue Strategy until 2030 : Resolution of the Cabinet of Ministers of Ukraine dated 12/27/2023 No. 1218-p. URL: https://zakon.rada.gov.ua/laws/show/1218-2023-%D1%80#Text (Last accessed: 30.04.2025).

8. On approval of the action plan for reforming local self-government and territorial organization of power in Ukraine for 2024–2027: Resolution of the Cabinet of Ministers of Ukraine; Plan, Measures dated 03/26/2024 No. 270-p. URL: https://zakon.rada.gov.ua/laws/show/270-2024-%D1%80#Text (Last accessed: 30.04.2025).

9. On approval of the Budget Declaration for 2025–2027: Resolution of the Cabinet of Ministers of Ukraine; Declaration dated 06/28/2024 No. 751. URL: https://zakon.rada.gov.ua/laws/show/751-2024-%D0%BF#Text (Last accessed: 30.04.2025).

10. What is OKR and how to implement it: the experience of the Ministry of Digital Economy Fedorov. Business News. URL: https://businessnews.in.ua/media/sho-take-okr-i-iak-ce-zaprovaditi-dosvid-mincifri-fedorova.html (Last accessed: 30.04.2025).

11. Official website of the Zaporizhzhia City Council. URL: https://zp.gov.ua/documents/82083-pro-zatverdzennia-koncepciyi-cifrova-strategiia-zaporizzia-2030 (Last accessed: 30.04.2025).

12. It became known what level of digitalization is in Zaporizhia region. Reconstruction of Zaporizhia. URL: https://vidbudova.zp.ua/stalo-vidomo-iakyi-riven-tsyfrovizatsii-u-zaporizkii-oblasti/ (Last accessed: 30.04.2025).

13. Official website of the Ministry of Digital Affairs of Ukraine. URL: https://thedigital.gov.ua/news/doluchaytesya-do-novikh-konkursiv-programi-tsifrova-evropa-na-2025-rik (Last accessed: 30.04.2025).

MARKOVA Svitlana,
Doctor of Economics, Professor, Professor of the Department of Business Administration and Foreign Economic Activity Management,
Zaporizhzhia National University,
Zaporizhzhia, Ukraine
ORCID: https://orcid.org/0000-0003-0675-0235
KALYUZHNA Yulia,
Candidate of Economic Sciences, Associate Professor of the Department of Human Resource Management and Marketing,
Zaporizhzhia National University,
Zaporizhzhia, Ukraine
ORCID: https://orcid.org/0000-0002-3335-6551
MOSTENSKA Tetiana,
Candidate of Economic Sciences, Associate Professor,
National Aviation University,
Kyiv, Ukraine
ORCID: https://orcid.org/0000-0001-6962-2463

1.3. THE ROLE OF ARTIFICIAL INTELLIGENCE IN ENSURING ECONOMIC STABILITY AND INFORMATION SECURITY IN UKRAINE

Introduction. In the context of rapid digital technology development and escalating global conflicts – especially of the hybrid type – artificial intelligence (AI) is becoming a strategic tool in ensuring national security and economic stability. AI technologies are increasingly applied both in the economic sector – for production optimization, forecasting, and process automation – and in the information space – for detecting and neutralizing fake news, manipulation, and cyberattacks. This necessitates a comprehensive study of AI's potential in two critical areas: economic development and information security.

Russia's ongoing war against Ukraine is accompanied by large-scale information aggression aimed at demoralizing society [1],

discrediting state institutions, and creating artificial chaos. Under these circumstances, AI can effectively filter and analyze vast amounts of information, automatically detect disinformation, and forecast risks arising from information influence. This strengthens the relevance of exploring AI's capabilities in strategic communications and countering hybrid threats.

At the same time, a wartime economy requires an innovative approach to modernization and recovery. The implementation of AI can drive economic growth through digital business transformation, development of hightech sectors, increased labor productivity, and cost reduction. Thus, the synergy between technological development and information space protection forms a new paradigm of national resilience, highlighting the importance of studying this issue amid today's challenges.

In the context of growing hybrid warfare threats and digital transformation, the use of artificial intelligence technologies to ensure economic security and counter disinformation becomes particularly relevant. These issues are actively studied by both Ukrainian and foreign scholars. In Ukraine, researchers such as Cherep O. and Cherep A. [8] examine the impact of digital technologies on the national economy and their role as a powerful tool for environmental protection and sustainable development [14]. Prokopenko O. analyzes digital security issues, while Nesterenko O. [9] explores the informatization of public administration. Internationally, significant contributions have been made by Yoshua Bengio [10], Kate Starbird, and Karsten Geier, who study ethical, informational, and security aspects of AI use.

The purpose of this article is to systematize approaches to using artificial intelligence technologies to enhance Ukraine's economic resilience, particularly through legislative, administrative, educational, and security mechanisms, and to formulate proposals regarding the state's role in these processes. The main objective is to identify strategic directions for AI application to strengthen economic security, analyze national and international experiences in countering disinformation

using intelligent technologies, and develop recommendations for cross-sectoral state policy in this field.

Presentation of Key Research Findings. Artificial intelligence is a branch of computer science focused on creating systems and algorithms capable of performing tasks that typically require human intelligence. This includes speech recognition, natural language processing, machine learning, computer vision, planning, and decision-making.

In 2024, the global AI market achieved significant financial indicators, reflecting its rapid growth and impact across various economic sectors. According to Precedence Research, the total AI market size in 2024 was approximately $638.23 billion, with forecasts projecting growth to $757.58 billion in 2025 and $3.68 trillion by 2034, representing an average annual growth rate of 19.2 %. Other sources, such as Exploding Topics, estimated the market at $621.19 billion in 2024, with projections reaching $2.74 trillion by 2032 [12].

The AIbased software market, in particular, is showing remarkable growth: in 2024, it reached $94.41 billion, with expectations to rise to $126 billion by 2025. Major tech companies like Microsoft and Alphabet (Google) reported significant revenue increases due to AI integration into their cloud services and advertising platforms. For example, Microsoft Azure saw a 33 % revenue increase, while Google's ad revenue grew by 8.5 % in the first quarter of 2024. Analysts note that to justify the current investment levels – approximately $200 billion in 2024 – revenues need to reach $600 billion, which has yet to be achieved [13].

Overall, 2024 became a turning point for the AI industry, marked by major financial achievements as well as challenges related to evaluating the real value and effectiveness of investments in this field.

The goal of AI is to develop programs that can independently learn, adapt to new conditions, and perform tasks without direct human intervention.

AI's strengths (see Table 1) include high-speed data processing, the ability to automate routine tasks, continuous learning and improvement

through machine learning, high task accuracy, and the capability to operate under heavy workloads without needing breaks. However, alongside these advantages, there are also weaknesses such as dependence on data quality, limited creativity and intuitive reasoning, difficulty adapting to rapidly changing environments, and ethical and social risks – such as the threat of job displacement. These issues require careful oversight and a responsible approach to AI implementation across various fields.

Table 1

Strengths and Weaknesses of Artificial Intelligence

Strengths of AI	Weaknesses of AI
High data processing speed – can handle massive amounts of data in a short time.	High dependency on data – inaccurate or incomplete data can lead to errors.
Process automation – reduces the need for manual intervention and increases productivity.	Limited adaptability – often requires retraining when conditions change.
Continuous improvement – machine learning enables AI to constantly improve its performance.	Lack of creativity – AI cannot generate new ideas like humans can.
Increased accuracy – can achieve high precision in tasks such as image or speech recognition.	Absence of emotions and intuition – AI lacks emotional intelligence and cannot make "human-like" decisions.
Efficiency in complex and repetitive tasks – capable of executing tasks that require precision and speed.	Ethical and legal issues – AI use may raise concerns about privacy and security.
Operation under heavy workloads – can function continuously without the need for rest.	Job displacement risk – automation through AI may lead to job losses in certain sectors.

According to Figure 1, India leads in the level of AI adoption among the surveyed countries, primarily due to the development of its technology sector and the widespread implementation of innovations.

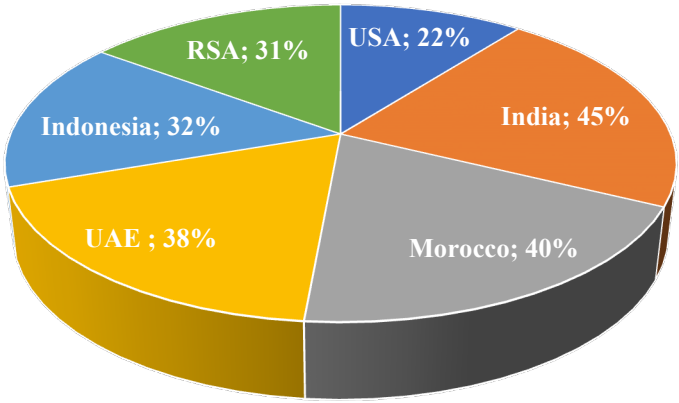

Figure 1. Countries with the Highest Use of Artificial Intelligence, According to 2024 Data

Source: compiled by the authors based on [4]

Morocco and the UAE also demonstrate high performance, indicating active digital transformation in these countries. The United States, despite substantial investments in AI, shows a lower level of usage among the general population, which may be linked to various factors, including technology accessibility and cultural characteristics.

The level of AI implementation can vary depending on the specific company and its digital transformation strategy (see Table 2).

Higher levels of AI implementation are observed in industries where automation and data analytics significantly impact the efficiency of business processes. Ukraine is actively developing AI adoption, particularly in healthcare, finance, and information technology sectors. AI technologies open new opportunities for economic growth by increasing productivity, automating routine processes, and improving the quality of management decisions. They enable enterprises to optimize production, reduce costs, and respond more quickly to market changes.

Thanks to big data analytics, AI helps forecast demand, identify risks, and develop effective development strategies. In the public

Table 2

Level of AI Implementation Across Various Industries as of 2024, Including in Ukraine and Internationally

Industry	AI Implementation Level	Main Areas of AI Usage
Financial Sector	58 %	Fraud detection, risk management, process automation, financial reporting
Healthcare	40 %	Improving treatment outcomes, medical diagnostics, personalized treatment
Retail	50 %	Inventory optimization, customer service personalization, sales analytics
Telecommunications	38 %	Network optimization, customer service, demand forecasting
Professional Services	72 %	Consulting, legal and accounting services, automation of routine tasks
Manufacturing	44 %	Automation of manufacturing processes, predictive maintenance, supply chain management
Information Technology	31.7 %	Software development, cybersecurity, data management
Logistics and Transport	47.5 %	Route optimization, inventory management, demand forecasting

Source: compiled by the authors based on [5]

sector, AI contributes to improving the efficiency of public service delivery, combating corruption, and transparent financial management. Implementing AI in key economic sectors can become a powerful driver of innovation and ensure the long-term competitiveness of countries in the global environment. Ukraine can effectively incorporate the experience of leading countries in AI adoption by adapting their

strategies to its own economic and social conditions. In particular, attention should be paid to investments in education and digital skills, as India has done, which allowed it to become a leader in AI adoption among developing countries.

Equally important is the creation of a national AI ecosystem – with support for startups, research centers, and partnerships between the state and business, as seen in the USA and UAE. Additionally, regulatory frameworks for the ethical and safe use of AI should be introduced, following the example of the European Union. Such an approach will allow Ukraine not only to accelerate economic growth but also to integrate into the global technological space.

A critical analysis of Table 3 shows a variety of approaches to AI implementation in different countries, influenced by their economic potential, political will, and the level of digital infrastructure development. For example, India has focused on mass digital education in response to its large youth population and the need to ensure access to the IT market – this approach is promising for Ukraine but requires substantial funding for education, which is currently limited. The UAE and USA demonstrate government initiatives and investments in innovation, but in Ukrainian realities, the lack of a stable national AI policy may complicate adapting these models. Meanwhile, the EU's experience in forming ethical and legal norms can be directly applied in Ukraine, considering its course toward European integration. However, transferring China's model of largescale automation to Ukrainian manufacturing currently seems premature, given the technical obsolescence of many enterprises and the lack of relevant investments.

Overall, the table outlines strategically valuable guidelines, but their successful application in Ukraine requires adaptation to the local context, institutional support, and consistent government policy.

In the current conditions of hybrid warfare, where information security is as important as physical security, the state of Ukraine plays a key role in the development and implementation of artificial intelligence technologies. Primarily, this involves creating a favorable regulatory and legal framework, providing investment support for

Table 3

Countries' Experience in AI Implementation Useful for Ukraine

Country	Useful Experience	How Ukraine Can Use It
India	Mass digital skills training	Expand AI educational programs in universities
UAE	National AI development strategy	Develop a national artificial intelligence strategy
USA	Support for startups and research centers	Create innovation hubs with government support
EU	Ethical and legal AI standards	Implement AI ethics and transparency standards
China	Large-scale AI integration in industry	Apply AI for production automation

Source: compiled by the authors based on [5; 6]

innovative businesses, and initiating strategic partnerships between the public sector, science, and IT companies. The use of AI contributes to improving the efficiency of public administration, ensuring economic growth through automation, big data analytics, and the development of new products.

At the same time, AI technologies enable the rapid detection and neutralization of fake news, manipulative narratives, and information attacks, which is vital for protecting the national information space. An active position of the state (Fig. 2) in this area is a guarantee of digital sovereignty, innovative breakthrough, and strengthening national resilience against the threats of the modern world.

The distribution of actions by sectors allows for a systematic definition of priorities and the delineation of responsibilities between government authorities, scientific institutions, and businesses. A particular emphasis is placed on legislative regulation, which is intended to ensure a balance between innovation and security, as well as to create conditions for the ethical use of AI. However, the actual implementation of such initiatives requires political will, funding, skilled personnel, and broad public dialogue.

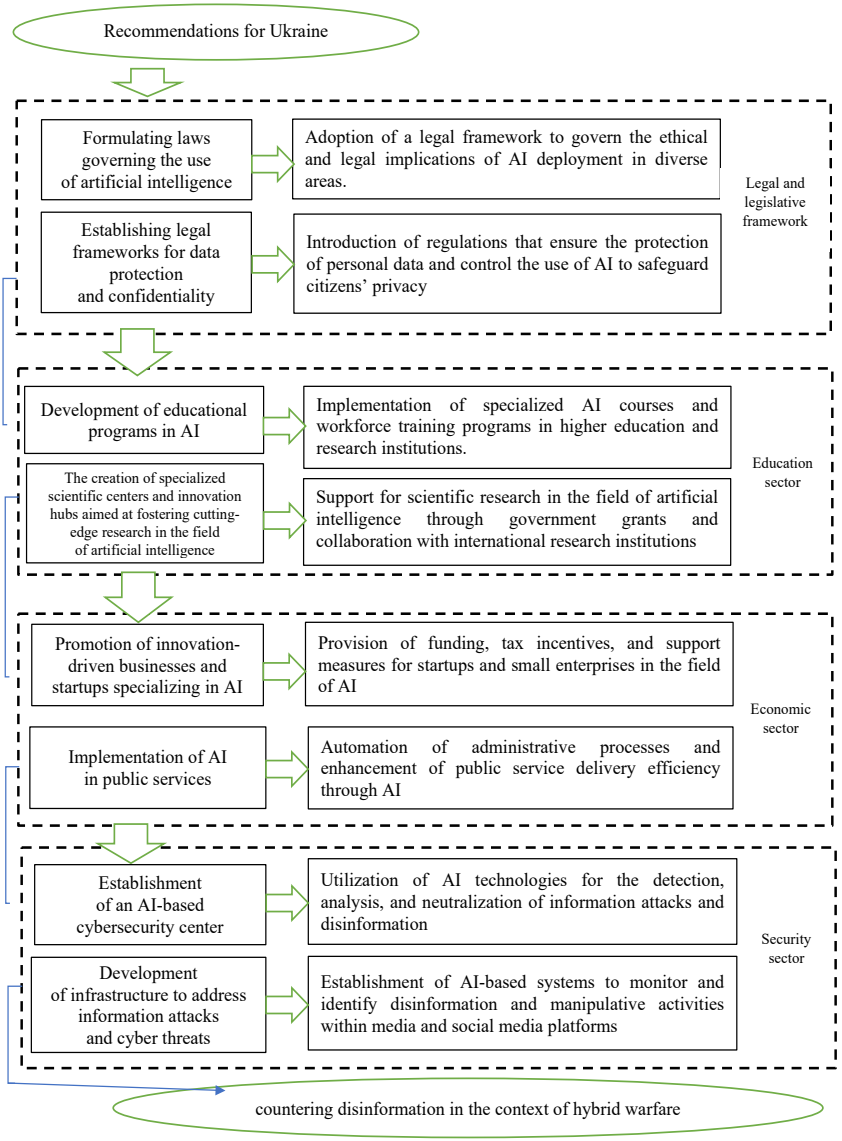

Fig. 2. Crosssectoral approach necessary for the effective implementation of artificial intelligence in Ukraine

At the same time, Fig. 2 reveals potential challenges: notably, the insufficiency of the current digital infrastructure, the brain drain of young specialists abroad, and the low level of digital literacy among part of the population. These factors may significantly slow down the practical realization of even well-planned government initiatives. Furthermore, in the security sphere, there is a need for extremely rapid response to threats, which requires flexible management mechanisms and fast policy adaptation. Therefore, to achieve strategic goals, the state must not only formulate a vision but also ensure effective tools for its implementation, relying on partnerships with the private sector and international organizations.

Ukraine has promising prospects for implementing modern approaches in government business analytics, using the experience of other countries. The introduction of business analytics systems integrated with AI will allow automatic identification of data trends, forecasting community needs, and resource planning, thereby increasing the effectiveness of management decisions. For example, the UK government actively uses business analytics to analyze open data, which promotes data-driven decision-making and increases government transparency. The Canadian experience also shows how open data platforms can engage citizens in the decisionmaking process. Additionally, automating data collection and analysis helps reduce reporting preparation time, enabling focus on strategic tasks. Citizen engagement in management processes can be enhanced by developing interactive platforms for accessing open data, which will improve transparency and legitimacy of decisions and increase trust in the government. As Canadian practice demonstrates [11], open data platforms actively facilitate citizen integration into decision-making, ensuring more effective governance. Active use of such technologies will enable Ukrainian government bodies to be more efficient, relying on factual data and citizen participation in important decisions.

Artificial intelligence is a key factor in strengthening national resilience amid hybrid warfare [15]. Its capabilities in detecting and neutralizing disinformation allow effective counteraction

to information aggression accompanying modern conflicts. By analyzing large volumes of data, AI helps timely detect fake narratives, cyberattacks, and manipulations that threaten public opinion and government institution functioning. This makes AI an important component of strategic communications and digital security systems. Simultaneously, AI opens new opportunities for economic growth during a war-induced crisis. AI technologies ensure digital transformation of enterprises, increased labor productivity, optimization of production processes, and development of high-tech sectors. Combined with investments in innovation and human capital, AI can drive economic modernization and reduce dependence on external factors. Thus, integrating AI into key state development sectors creates prerequisites for strengthening the country's economic, informational, and security spheres.

Conclusions. This article reveals the role of artificial intelligence as a key factor in ensuring Ukraine's economic resilience and information security in the context of hybrid warfare. AI is an effective tool for detecting and neutralizing disinformation, allowing for rapid response to information threats and counteracting manipulative influences on public opinion. Its ability to process large amounts of data facilitates the identification of fake narratives, cyberattacks, network anomalies, and risks to critical infrastructure. This makes AI an important component of digital security and an effective tool for strategic communications against information aggression.

At the same time, AI opens new possibilities for stimulating the economy amid a prolonged crisis. AI technologies enable digital transformation of production, process automation, logistics optimization, cost reduction, and labor productivity increase. Their implementation lays the foundation for developing innovative sectors, reducing dependency on imported technologies, expanding export potential, and strengthening Ukraine's position in global markets. A cross-sectoral approach to AI implementation – coordinating actions of the state, business, academia, and the IT industry – plays a crucial role in this process.

However, alongside the advantages, AI also has several weaknesses. Ethical issues related to the use of algorithms in decisionmaking may hinder wide AI adoption. Problems of privacy and personal data protection, as well as potential new cyberthreats, require careful consideration. AI's weaknesses in some areas are also evident in its potential for incorrect or biased decisions, especially when processing and analyzing lowquality data. The article also discusses risks related to AI's impact on the labor market and social sphere.

The experience of leading countries that successfully integrate AI into public administration, defense, economy, and education is analyzed. Research shows that creating a national AI development strategy in Ukraine, considering security challenges and social needs, will ensure the country's long-term resilience, competitiveness, and independence.

List of used sources

1. Dashko I., Cherep O., Kalyuzhna Yu., Maltiz V., Mykhailychenko L. Artificial Intelligence as a Tool to Counter Disinformation in Wartime: Experience and Prospects of Application in Ukraine. *Current Issues of Economic Sciences*. 2025. No. 7. URL: https://a-economics.com.ua/index.php/home/article/view/185 (Last accessed: 05.05.2025).

2. Cherep O., Dashko I., Bekhter L., Pidlisnyi R. Advantages and Challenges of Ukraine's Economic Digitalization. *Technology*. 2024. No. 1(9). P. 131–135. URL: http://ujae.org.ua/wp-content/uploads/2024/02/ujae_2024_r01_a21.pdf (Last accessed: 05.05.2025).

3. Voronkova V., Cherep A., Cherep O. Influence of Global Digitalization Trends on Contemporary Economic Development: New Opportunities and Challenges. *Humanities Studies*. 2023. No. 17 (94). P. 200–208.

4. Global Trends in AI Adoption by Country – Quanta Intelligence. URL: https://quantaintelligence.ai/2024/09/17/technology/global-trends-in-ai-adoption-by-country (Last accessed: 05.05.2025).

5. Top 10 AI Adoption Index 2024 – GenSpark. URL: https://www.genspark.ai/spark/top-10-ai-adoption-index-for-2024/38ee5299-42c4-47fb-a14f-206e413827d1 (Last accessed: 05.05.2025).

6. McKinsey & Company – The State of AI in 2024. URL: https://www.mckinsey.com/capabilities/quantumblack/our-insights/the-state-of-ai-2024 (Last accessed: 05.05.2025).

7. USA – Support for Startups and Research Centers. *AI Technology Adoption by Industry – 2024*. URL: https://www.restack.io/p/ai-technology-adoption-answer-trends-in-ai-adoption-2024 (Last accessed: 05.05.2025).

8. Voronkova V., Cherep A., Cherep O. The Concept of Blockchain Economy as a New Type of Economy in the Context of Digitalization. *Economic sciences*. URL: https://eo.kiev.ua/resources/zmist/zmist_mono_8_dev/Monograph_8-54-61.pdf (Last accessed: 05.05.2025).

9. Nestirenko O., Zharinov S. Digitalization of the Evaluation Process of Scientific Institutions Supported by the State. *Science, Technology, Innovation*. 2023. No. 4. URL: https://nti.ukrintei.ua/wp-content/uploads/2024/12/Нестеренко_4-2023.pdf (Last accessed: 05.05.2025).

10. Yoshua Bengio. Reasoning through arguments against taking AI safety seriously. URL: https://yoshuabengio.org/2024/07/09/reasoning-through-arguments-against-taking-ai-safety-seriously/ (Last accessed: 05.05.2025).

11. Analysis of sectoral trends and preliminary vision for AI development. URL: https://winwin.gov.ua/assets/files/%D0%A3%D0%9A%D0%A0%20WINWIN_AI_1.pdf (Last accessed: 05.05.2025).

12. Artificial Intelligence Skyrocketing, Shaking the Market URL: https://www.globenewswire.com/news-release/2025/02/11/3024340/0/en/Artificial-Intelligence-Skyrocketing-Shaking-the-Market-with-3-680-47-Bn-by-2034.html?utm_source=chatgpt.com (Last accessed: 05.05.2025).

13. NEW Artificial Intelligence Statistics (Apr 2025). URL: https://explodingtopics.com/blog/ai-statistics?utm_source=chatgpt.com (Last accessed: 05.05.2025).

14. Voronkova V., Nikitenko V., Cherep A., Cherep O. The Concept of Platform Economy as a Type of Network and Internet Economy. *Current Issues of Education and Science in Wartime: Proceedings of the First Scientific and Practical Online Conference with International Participation* "*Current Issues of Education and Science in Wartime*" (Kyiv, June 6–7, 2023). Kyiv : SE "Express-Ob'yava", 2023. P. 7–20.

15. Markova S., Markov I. Advantages of Accelerating the Digitalization of the Economy as a Basis for State Development. *Implementation of the European Vector of State Economic Development through Digitalization* : Collective Monograph / ed. by A. Cherep, I. Dashko, Yu. Ogrenyich, O. Cherep, V. Helman. Zaporizhzhia: Publisher FOP Mokshanov V. V., 2024. P. 179–189. URL: https://dspace.znu.edu.ua/jspui/handle/12345/24078 (Last accessed: 05.05.2025).