

ARTIFICIAL INTELLIGENCE IN HIGHER EDUCATION: OPPORTUNITIES AND CHALLENGES FOR EUROPEAN SUSTAINABILITY

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Artificial intelligence (AI) is rapidly transforming higher education by enhancing teaching methodologies, administrative efficiencies, and research capabilities, with profound implications for sustainability. This review analyzes international and national policy frameworks, including UNESCO's ethical guidelines and competency frameworks (UNESCO, 2021, 2024), the European Union's AI Act (Regulation (EU) 2024/1689) and EU Digital Education Action Plan (2021-2027), key U.S. initiatives like the U.S. Department of Education's AI guidance and Executive Order (The White House, 2025), China's strategic digitalization guidelines (2025), and AI education policies and recommendations of the Ministry of Education and Science of Ukraine (2025). These documents reveal diverse approaches, from human-centered ethics to regulation-driven innovation and state-led integration. Opportunities include personalized learning, resource optimization, and global collaboration, while risks encompass ethical concerns, inequity, academic integrity issues, and overreliance. Generally, recommendations emphasize harmonizing policies, increasing AI literacy, ensuring equitable access, and safeguarding human-centered pedagogy to maximize AI's potential in sustainable higher education, particularly in contexts of Ukraine's post-war recovery.

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Introduction

Artificial intelligence (AI) as defined in the EU AI Act is "a machine-based system that is designed to operate with varying levels of autonomy and that may exhibit adaptiveness after deployment, and that, for explicit or implicit objectives, infers, from the input it receives, how to generate outputs such as predictions, content, recommendations, or decisions that can influence physical or virtual environments" (European Union, 2024). Currently, AI is reshaping higher education landscapes globally. From personalized learning paths to automated administrative processes, AI enhances efficiency and innovation, aligning with the United Nations' Sustainable Development Goals (SDGs) to promote inclusive and equitable quality education (SDG 4) and foster sustainable development. In the context of European sustainability, AI offers tools to simulate environmental scenarios, optimize resource use, and support interdisciplinary research on climate change and green technologies. However, its adoption raises ethical, legal, and pedagogical challenges, including data privacy, bias, and the potential erosion of critical thinking skills. Recent academic research on AI in higher education highlights its dual potential. A study (Nikolopoulou, 2025) explores how generative AI can be a tool for sustainable education, enabling case analyses

and promoting critical thinking in complex environmental issues. Similarly, (Bagherimajd and Khajedad, 2025) propose a model for sustainable education that integrates AI to enhance learner engagement and resource efficiency. However, scholars also voice concerns. Researchers reasonably warn of the risks of over-personalization, which may lead to intellectual passivity and limit the development of robust analytical skills (Sack and Little, 2024). The growing body of literature on AI's impact on academic integrity and equity further underscores the need for careful policy and institutional guidance.

This review provides an in-depth examination of key international, European, Ukrainian, U.S., and Chinese policy documents that frame AI's deployment in higher education. It analyses research on AI's applications in sustainability, evaluates benefits and risks for students and educators, and offers recommendations for balanced integration. Based on UNESCO's human-centered ethical frameworks, the EU's risk-based regulations, U.S. literacy-focused initiatives, and China's strategic digitalization plans, the article underscores AI's role in advancing sustainability while addressing regional disparities, particularly in post-conflict settings like Ukraine. The analysis is grounded in evidence from recent studies and official reports, emphasizing the need for collaborative, equitable approaches to harness AI's potential without compromising educational integrity.

UNESCO's Human-Centered Ethical AI Framework

UNESCO's approach to AI in education is rooted in its 2021 publication "AI and Education: Guidance for Policy-makers," updated with frameworks and initiatives through 2024, emphasizing a human-centered, ethical deployment to foster inclusion, equity, and sustainability (UNESCO, 2021, 2024). The Beijing Consensus (2019) laid the foundation, advocating for AI to accelerate SDG 4 by innovating teaching and learning while addressing inequalities (UNESCO, 2019). Key tools include the Readiness Assessment Model (RAM), which helps countries gauge AI preparedness in education systems, and Educational Impact Assessments (EIA) for evaluating AI projects' effects on learners and teachers (UNESCO, 2024). UNESCO's AI Competency Frameworks for students and educators outline skills such as understanding AI's potential and risks, enabling critical reflection and ethical use (UNESCO, 2024). These frameworks promote overcoming digital divides, respecting cultural diversity, and upholding human rights, with initiatives like global seminars assisting over 50 countries in implementation. In higher education, UNESCO advocates for AI to support personalized learning and research on sustainability, but warns of risks like algorithmic bias exacerbating inequalities, particularly in resource-limited regions (UNESCO, 2021).

European Union Policy on AI in Education

The EU AI Act (Regulation (EU) 2024/1689), adopted on June, 2024, establishes a risk-based framework to govern AI, categorizing systems from prohibited to minimal risk and emphasizing transparency, human oversight, and compliance (European Union, 2024). In education, Annex III classifies AI for assessing learning outcomes, monitoring behavior, or determining access to institutions as high-risk, requiring conformity assessments, risk management, and data quality standards. Article 5 prohibits practices like emotion inference in schools, except for medical reasons, due to discrimination risks. Article 4 mandates AI literacy training for staff, while Article 26 requires human oversight for high-risk systems, with deployers (e.g., universities) ensuring competence and transparency (European Union, 2024). Passage 56 promotes AI to enhance digital skills and critical thinking in education, linking to sustainability through resource-efficient AI (Art. 40). The Act's

governance includes the European AI Board (Art. 85) and national authorities, with fines up to 7% of turnover for violations (Art. 89). For higher education, this fosters trustworthy AI in sustainability simulations but imposes administrative burdens, potentially favoring larger institutions (Hunton Andrews Kurth LLP, 2024).

In addition to the EU AI Act, the EU Digital Education Action Plan (2021-2027) promotes the use of digital technologies, including AI, to foster quality, inclusive, and accessible education, with a strong focus on digital literacy and skills for a green transition. Many European universities are already leading with innovative AI initiatives. For instance, the University of Bologna is piloting an AI-powered system to optimize energy consumption across its campus buildings, demonstrating a practical application of AI in achieving sustainability goals. This project utilizes predictive analytics to manage heating, ventilation, and air conditioning (HVAC) systems and lighting, reducing the university's carbon footprint and aligning with both the EU's sustainability and digital education strategies (University of Bologna, 2024).

United States Federal and State-Level AI Education Policies

The U.S. Department of Education's "Artificial Intelligence and the Future of Teaching and Learning" (2024) provides guidance on AI's ethical use, emphasizing literacy and equity, with updates in 2025 proposing supplemental priorities for advancing AI in education (U.S. Department of Education, 2024, 2025). The Executive Order on Advancing AI in Education (April 2025) establishes a framework for integrating AI literacy into curricula, promoting teacher training and equitable access (The White House, 2025). Key initiatives include the Department's AI inventory for tools like speech-to-text and the \$1 billion Google.org grant for AI learning. State-level policies, tracked by the Education Commission of the States (2024), mandate AI instruction and professional development, with at least seven bills in 2025 calling for oversight and sandboxes. These approaches focus on personalized learning and outcomes, but disparities in adoption highlight needs for national coordination (Education Commission of the States, 2024). For sustainability education, U.S. policies encourage AI for climate modeling, though a voluntary nature may limit impact in under-resourced areas.

Leading U.S. universities are at the forefront of AI integration for sustainability. For example, Stanford University's Center for AI in Science and Technology has developed machine-learning models to predict the spread of wildfires and optimize renewable energy grid management. Similarly, the Massachusetts Institute of Technology (MIT) offers courses that use AI tools to simulate the impacts of climate change on coastal communities, providing students with hands-on experience in addressing real-world sustainability challenges (Stanford University, 2025; MIT, 2025).

China's Strategic AI Integration in Higher Education

China's "Guideline on Accelerating Education Digitalization" (April 2025), issued by the Ministry of Education promotes AI to reform education, cultivating critical thinking and problem-solving skills (Ministry of Education of China, 2025). It mandates AI in primary/secondary schools (eight hours/year from September 2025) and extends to higher education through research centers and interdisciplinary programs (Global Institute for National Capability, 2024). The "New Generation Artificial Intelligence Development Plan" (2017, updated 2025) integrates AI into curricula for healthcare, finance, and environmental studies, emphasizing social problem-solving (Rehman et al., 2025). Initiatives like the AI Innovation Action Plan (2025) enhance R&D and training quality, with

universities fostering collaborative environments. Policies address regional disparities but prioritize economic growth, potentially overlooking ethical gaps (Bibi et al., 2024).

This state-led approach has enabled large-scale AI deployment in leading Chinese institutions. Tsinghua University, for example, has established a dedicated AI for Sustainable Development program that leverages machine learning to analyze satellite imagery for urban planning and environmental monitoring (Tsinghua University, 2025). Peking University has integrated AI into its School of Environmental Science and Engineering to help students simulate and optimize waste management and water treatment systems (Peking University, 2025). These examples illustrate the rapid and centralized adoption of AI in China's higher education system.

Ukraine's Emerging AI Education Policies

The Ministry of Education and Science of Ukraine in collaboration with the Ministry of Digital Transformation issued the Recommendations for the Responsible Implementation and Use of Artificial Intelligence Technologies in Higher Education Institutions (April 2025) providing methodological guidance for ethical AI adoption, emphasizing policy development, risk assessment, and training (Ministry of Education and Science of Ukraine, 2025). These recommendations, aligned with the EU's framework for accession, advise universities to create institutional AI policies, establish ethical committees, and conduct mandatory training for faculty and students on AI literacy. They also highlight the importance of using AI to support research and educational processes while maintaining human oversight. Among other national documents, the White Paper on AI Regulation in Ukraine (2024) outlines transparency and data protection, with a roadmap for national AI regulation (Ministry of Digital Transformation of Ukraine, 2024). These efforts align with EU standards for accession, but challenges like resource gaps persist (AI House, 2024).

In response to the Ministry of Education and Science of Ukraine's recommendations, Ukrainian universities are adopting their own institutional documents on AI policies. For example, the National University of Food Technologies, Kyiv has implemented a comprehensive AI Policy (2025). The policy outlines clear guidelines for students and faculty on the ethical use of AI for research, assignments, and administrative tasks, with a strong focus on addressing academic integrity amid post-war recovery challenges (National University of Food Technologies, 2025). Taras Shevchenko National University of Kyiv, for example, is developing AI-powered platforms to digitize and manage its academic archives and research data, an essential step in preserving intellectual heritage and facilitating international collaboration.

AI Applications for Sustainability: Opportunities and Risks

AI's transformative role in education includes personalized learning through adaptive platforms like Khan Academy's Khanmigo, which tailors content to individual needs, improving engagement in climate studies (Khan Academy, 2023). Generative AI enables interactive scenarios, such as ChatGPT for sustainability case analyses, fostering critical thinking (Nikolopoulou, 2025; Bagherimajd and Khajedad, 2025). Predictive analytics in tools like Google Earth Engine can simulate environmental impacts, e.g., the Kakhovka Dam destruction, aiding ecological decision-making (Google, 2023). Enterprise Resource Planning (ERP) systems optimize institutional resources, aligning with SDG 12 (Smith et al., 2024). Case studies from the UK Quality Assurance Agency show AI enhancing digital skills and Education for Sustainable Development (ESD), though equitable access remains a challenge (Quality Assurance Agency for Higher Education, 2024). In

Ukraine, AI could support post-war recovery education, but many challenges should be overcome, including infrastructure and resource limits. On the other hand, broad involvement of AI both in national education system and real economy may boost the country's development.

Thus, AI offers personalized pathways and provides a real-time feedback, boosting student outcomes in sustainability. For professors, it reduces workloads through drafting tools, enabling a focus on mentorship. The dialogue below of the author with Google Gemini illustrates how practical and supportive AI may be:

Prompt (I.Ya.): How professors should start to use AI in their classes on European Sustainability? Please, give me the answer as an expert in AI application in education.

Response (Gemini): Hello! That's a great question, and a very practical one for any professor looking to innovate. As an expert in the field, I'd say the best way for a professor to start using AI in a European Sustainability class is by adopting a phased, purpose-driven approach. Rather than trying to integrate complex, high-risk systems all at once, they should begin with simple tools to enhance existing tasks, then move toward more collaborative, student-centered projects.

Here's a step-by-step guide on how a professor could begin.

Phase 1: Automate and Augment

The first step is to use AI to streamline administrative and preparatory tasks. This is the easiest way to get started, as it reduces the professor's workload and doesn't require complex pedagogical changes.

- 1. Use Generative AI for Content and Outlines: Professors can use tools like ChatGPT or Gemini to draft lecture outlines on topics like climate policy, circular economy models, or renewable energy technologies. They can also ask the AI to generate a list of relevant case studies from specific European countries, or to draft practice questions for a quiz. This saves time and ensures a comprehensive overview of the topic.*

- 2. Summarize and Synthesize Research: A professor can use tools like Perplexity AI to quickly summarize recent academic papers on topics such as the EU's Green Deal or sustainable urban planning. They can also use it to find key research gaps for a new research project. This makes staying current with the rapidly evolving field of sustainability much more efficient.*

- 3. Create Engaging Quizzes and Activities: AI can be used to generate interactive quizzes, flashcards, or short simulations based on course material. For example, a professor could ask an AI to create a scenario-based quiz where students have to make decisions about a city's waste management plan and see the environmental and economic consequences of their choices.*

Phase 2: Introduce AI to Students

Once a professor is comfortable with the tools, the next step is to introduce them to students in a structured and ethical manner. The focus here is on promoting AI literacy and critical thinking.

- 1. Pilot Low-Stakes Assignments: A professor could assign a small project where students use AI. For example, they could ask students to use an AI to create a sustainability report for a mock company and then require them to critically evaluate the AI's output, correcting any inaccuracies or biases. This teaches them about both the power and the limitations of the technology.*

- 2. Facilitate AI-Powered Research: Encourage students to use AI as a research assistant, not a replacement for their own work. For instance, they could use it to brainstorm thesis topics, find initial sources for a literature review, or even draft the introduction to a paper. The professor would then require them to cite all their sources and explain their research process, including their use of AI.*

3. *Teach Critical Evaluation: It's crucial to teach students about AI hallucination—the phenomenon where AI models confidently present false information as fact. Professors should make it a key part of the curriculum that any information from an AI must be verified from a credible, primary source. This protects academic integrity and hones a vital skill for the digital age.*

Phase 3: Deepen Integration with Hands-On Projects

The final phase involves using AI for more advanced, collaborative projects that directly align with the course's sustainability objectives.

1. *AI for Data Analysis and Modeling: In a sustainability class, students could use AI tools to analyze large environmental datasets. For instance, they could use a platform like Google Earth Engine to analyze satellite imagery to study the impact of deforestation in the Amazon or a Python script to analyze European energy consumption data over the last decade.*

2. *Creating Digital Twins and Simulations: Advanced courses could use AI to create digital twins—virtual models of real-world systems—of a city's energy grid or a company's supply chain. Students could then use the model to run simulations to test different sustainability interventions, such as adding more solar panels or optimizing transportation routes.*

3. *Focus on Collaborative Problem-Solving: A professor can set up a class project where teams of students use AI to solve a real-world sustainability challenge. For example, one team could use AI to analyze public transit data to propose a new, more sustainable transit network for a European city, while another team uses it to model the environmental impact of a proposed construction project.*

By starting with small, manageable steps and building up to more complex applications, professors can effectively integrate AI into their European Sustainability classes, equipping students with the skills they need to tackle the challenges of the future while safeguarding academic integrity (Personal communication with Google Gemini, 2025).

This example clearly demonstrate how useful AI may be in both strategic planning and everyday academic activities, keeping in mind both new opportunities and limitations of current AI models.

Furthermore, AI tools like Perplexity AI may become invaluable for academic research. Professors and students can use such tools to quickly generate summaries of academic papers, identify key research gaps, and organize complex literature reviews, thereby accelerating the research process (Perplexity AI, 2025). Students also can use these tools to better understand dense academic texts and identify relevant sources for their assignments, fostering a more efficient and targeted approach to learning.

AI risks include overreliance leading to intellectual passivity and diminished critical thinking, particularly in sustainability where nuanced analysis is needed (Sack & Little, 2024; Times Higher Education, 2024). Privacy concerns, bias, and unequal access exacerbate inequalities, especially in Ukraine (AI House, 2024). Institutional challenges like inconsistent training and excessive accountability impede adoption, with varied readiness across regions (Education Commission of the States, 2024).

A significant technical challenge is AI hallucination, where AI models generate false or misleading information that is presented as factual. In academic contexts, this poses a severe risk to academic integrity and the quality of research (Warraich et al, 2025). Students and faculty must be trained to critically evaluate AI-generated outputs and verify information from reliable sources.

On a broader scale, there are existential risks to humanity from the improper development and deployment of AI. While this may seem a distant concern for educational policy, the academic community has a responsibility to consider these long-term implications, ensuring that AI is developed ethically and with human well-being at its core (Growiec, 2024). The proper management of AI in education is a small but critical step in ensuring that humanity maintains control over its most powerful technologies.

Conclusions

Artificial Intelligence's potential in higher education for sustainability is vast, supported by diverse frameworks from UNESCO's ethical guidance to the EU AI Act's risk management. Ambitious initiatives like U.S. literacy programs or China's broad implementation of AI into all levels of education offer pathways for innovation, but should be always keep in mind risks and challenges of AI. The EU policy on AI implementation, on the other hand, implies more strict regulations and careful control. Generally, most international and national recommendations include harmonizing policies, enhancing AI literacy through training, ensuring equitable access via infrastructure investments, and safeguarding academic integrity with human oversight. Similar recommendations were adopted by Ukraine's Ministry of Education and Science and may be a basic for active but controllable implementation of AI in national higher education, fostering relevant education for sustainable development and national prosperity.

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Conflict of interest

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