Review scientific paper DOI: 10.56461/iup_rlrc.2026.7.ch3

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ADVANCING THE INTEGRATION OF ARTIFICIAL INTELLIGENCE IN THE CROATIAN HIGHER EDUCATION

Artificial Intelligence constitutes a pivotal driver of digital transformation, permeating all spheres of life and labor. In this paper, the authors focus on the modalities and implications of AI implementation within the higher education (HE). AI technologies have the potential to personalize learning experiences, automate administrative tasks, reduce workloads, provide real time feedback, and enhance student engagement. Concurrently, they pose risks regarding plagiarism, bias, and the erosion of academic integrity. This paper seeks to examine the extent of AI regulation and application within Croatian higher education and, based on the research findings, formulate recommendations for further systemic integration.

The first part of the paper establishes a theoretical framework based on an analysis of AI implementation domains in HE. The second part presents the research findings concerning European states that have developed optimal policies and institutional practices for AI integration, based in the theoretical framework. The third part of the paper focuses on the scope of AI regulation within the Croatian context, encompassing both national and institutional levels. Furthermore, specific areas of AI utilization within HE are presented. The final part encompasses recommendations for the efficient implementation and responsible use of generative AI within Croatian universities, as well as other HE institutions where digital transformation remains in its nascent stages.

Keywords: artificial intelligence, Croatia, European practices, higher education, regulation and integration.

1. INTRODUCTION

Emerging paradigms, catalyzed by technological and societal advancements resulting from the pervasive utilization of Information and Communication Technologies, have initiated a transformative process reconfiguring all sectors, including higher education. Digitalization

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has effectively superseded printed materials with educational software, web-based platforms, electronic libraries, and virtual classrooms. Concurrently, numerous traditional higher education institutions (HEI) have integrated online components into their curricula, offering a synthesis of classroom-based and digital instruction, commonly conceptualized as hybrid and blended learning. Notwithstanding that learning is not an exclusively individual endeavor, online education benefits students by facilitating self-paced instruction, as well as personalized feedback and pedagogical support (Schuetze, de Vries & Mendiola, 2024, p. 7). The era of digital intelligence denotes a phase characterized by the progressive integration of informatization and digitalization, propelled by pivotal technologies such as Big Data, cloud computing, AI, the Internet of Things (IoT), and blockchain. These technologies have achieved widespread adoption and are substantively reshaping societal processes within the current technological revolution.

The integration of AI into higher education represents the most significant technological and pedagogical innovation since the digital revolution of the late 20th century. The emergence of large language models is fundamentally altering the ontology of learning, instruction, and scholarly creation. AI technologies possess the potential to individualize learning experiences, automate administrative functions, mitigate workloads, provide instantaneous feedback, enhance student engagement, and optimize decision-making processes (UNESCO, 2021, pp. 13-23). Educational policies must necessitate adaptation on a global level. Consequently, this paper seeks to examine the extent of AI regulation and application within Croatian higher education and, based on the research findings, formulate recommendations for the further integration of the AI system.

1.1. Paper Structure and Methodology

This paper is organized into four interrelated chapters, utilizing a multi-methodological approach to examine the regulatory and practical aspects of AI in HEIs. The first part of the paper is dedicated to formulating a theoretical framework that serves as the foundation for subsequent research. Through this framework, the authors aim to encompass and analyze the key domains of potential AI implementation in HEIs. By examining scholarly literature, professional reports, and ethical standards for AI application, five such domains were identified and elaborated in the second chapter.

In accordance with the defined theoretical framework, the third chapter presents best practice examples among European countries. For each identified domain of AI application in HEIs, a leading country was analyzed. The authors selected these countries based on an extensive review of scholarly and professional literature, as well as a desk review of strategic documents from states that indisputably lead in the field of digital transformation.

Regarding Croatia, the process of digital transformation in higher education has commenced but remains in its early and fragmented stages. Consequently, the fourth chapter analyzes the regulatory framework at both national and university levels concerning AI application in the teaching, scientific, and professional activities of higher education institutions in the Republic of Croatia. Furthermore, specific areas of AI integration within HEI are identified. This analysis employs a desk review of the legal framework and strategic documents, alongside a descriptive method to characterize Croatian practice. The research encompassed all public and private universities registered in the Register of Higher Education Institutions maintained by the Ministry of Science, Education, and Youth.

Finally, in the fifth chapter, the authors formulated recommendations for the efficient implementation and responsible use of generative AI within Croatian universities, as well as other HEIs where digital transformation remains in its nascent stages. European best practice examples serve as the basis for formulating these recommendations, which are directed toward each of the key domains of potential AI implementation in HEIs. To contrast European and Croatian practices, the comparative method will be applied, while a constructive approach will be utilized for the formulation of the final recommendations.

2. THEORETICAL FRAMEWORK FOR IDENTIFYING NECESSARY REGULATORY DOMAINS OF AI APPLICATION IN HIGHER EDUCATIONT

According to contemporary research, key areas of AI implementation can be categorized into five core domains: pedagogical innovation (Mrnjaus, Vrcelj & Kušić, 2023; Pedro *et al*., 2026), learning analytics (Liu *et al*., 2023; Ouyang, Xu & Cukurova, 2023), automation of evaluation processes (Kadel, 2024; Lynch, 2026), and faculty professional development (Al-Zahrani, 2024), while maintaining continuous regard for ethical and societal implications (Dabis & Csaki, 2024; Mićunović & Bosančić, 2025).

2.1. Pedagogical Innovations and Student-Centered Learning

The integration of AI into pedagogy denotes a transition from reactive to proactive instruction. Intelligent Tutoring Systems utilize algorithms to model student knowledge, identifying specific gaps in understanding before they constitute impediments to academic progress. According to Zawacki-Richter *et al*. (2019, p. 4), these platforms facilitate asynchronous learning tailored to an individual's cognitive load, thereby minimizing cognitive saturation and optimizing information retention. Furthermore, the application of Large Language Models enables students to assume the role of an "active researcher" through simulated dialogues with virtual mentors. In this capacity, students engage in structured problem-solving tasks, which foster independent inquiry and discovery-based learning. Okonkwo & Ade-Ibijole (2021, p. 6) emphasize that chatbots in higher education do not merely serve administrative functions but also stimulate Socratic dialogue, providing instantaneous feedback and mitigating the sense of isolation inherent in distance learning.

This process is further intensified through the human-in-the-loop concept, wherein AI assists the educator in creating dynamic instructional materials that adapt in real-time based on group dynamics. During the instructional period, AI monitors student responses, for instance, through digital assessments or task completion speed, enabling the educator to receive real-time analytics and subsequently adjust pedagogical methods. Should the data indicate a collective lack of comprehension regarding a specific graphical representation, the AI instantaneously generates supplementary examples or simplified visualizations. Holmes, Bialik & Fadel (2022, p. 151) emphasize that AI can generate personalized case studies or assessments targeting specific student interests, thereby positioning intrinsic motivation at the core of the educational process.

Ultimately, this transformation is manifested in the support provided to students with developmental disabilities. Through instruments such as advanced speech-to-text systems and personalized screen readers that adapt content formatting for dyslexic users, a higher degree of inclusivity is achieved. Consequently, AI transcends its role as a mere efficiency tool

and becomes an instrument for achieving educational equity, ensuring that every individual possesses access to resources in a manner that best aligns with their neurodivergent profile or physical predispositions.

2.2. Learning Analytics and Predictive Modeling

Learning Analytics utilizes Educational Data Mining to identify complex behavioral patterns that precede academic success or failure. Through the analysis of "digital footprints", specifically time spent on designated activities, frequency of repository access, and the quality of forum interactions, HEI can develop precise predictive models. Fahd, Miah & Ahmed (2014, p. 4) emphasize that these models can identify students at risk of attrition with high accuracy (frequently exceeding 80%) as early as the first semester, thereby enabling proactive intervention by advisory services.

In contrast to traditional end-of-semester reports, Yang, Wu, and Ogata (2024, p. 36) noted that personalized feedback mechanisms allow students to become more cognizant of their habits and more actively adjust their learning strategies. Further advancement is represented by affective computing which, through machine vision and deep learning, recognizes states such as frustration, boredom, or cognitive fatigue with an accuracy surpassing 90% (Aly & Alotaibi, 2025, pp. 3–4). As stated by Salloum *et al.* (2025, p. 14), the integration of emotional intelligence into AI systems allows platforms to dynamically calibrate the complexity of material, offering empathetic support or supplementary resources at the moment the system detects a decline in motivation or high cognitive exertion. However, this level of data collection raises significant concerns regarding the continuous surveillance of students. Sclater (2017, p. 127) warns that excessive monitoring may adversely affect academic freedom and student creativity, as individuals might begin to conform to "algorithmic expectations" rather than authentically exploring the subject matter. Consequently, contemporary research focuses on the development of transparent analytics, wherein students retain insight into which data are collected and the parameters upon which the system generates recommendations, thereby strengthening institutional trust.

2.3. Automation of Student Assessment and Grading

The application of Natural Language Processing facilitates the automated assessment not only of multiple-choice examinations but also of complex written assignments. Research by Lim *et al.* (2021, pp. 1880–1882) demonstrates that contemporary Automated Essay Scoring (AES) can achieve a correlation with human experts exceeding 0.90, signifying that the system's determinations align with the evaluations of experienced educators in nine out of ten cases, albeit with incomparably superior processing velocity. AES systems provide a high degree of reliability and consistency, as they are not susceptible to human factors such as fatigue, mood, or cognitive bias, which frequently result in inter-rater or intra-rater inconsistencies over time. A pivotal advantage of these systems is not merely the final summative grade but the provision of formative, real-time feedback. Rather than receiving a static numerical value, the student is provided with instantaneous guidance regarding argumentative structure, textual cohesion, and grammatical precision.

Furthermore, automation facilitates AI-assisted peer-assessment, thereby fostering the development of critical evaluation skills among students themselves. Consequently, the assessment process transcends its role as a purely hierarchical act and becomes an integral

component of social learning. In the context of academic integrity, tools limited to comparing text against existing databases have become insufficient, as AI generates novel, original content that is not extant elsewhere. Therefore, Dawson (2021, p. 123) asserts that higher education must evolve toward assessment tasks that necessitate critical thinking which AI cannot readily replicate, such as reflection on personal experience or the resolution of highly specific problems.

2.4. Faculty Professional Development and Digital Skills

In the era of digital transformation, faculty enhancement necessitates systematic professional development that transcends fundamental technical training. Educators must be capable of identifying model "hallucinations", understanding the limitations of large language models within specific scientific domains, and guiding students toward the ethical utilization of these instruments. A pivotal skill increasingly involves the proficiency to formulate instructional prompts that position artificial intelligence as an interactive tutor. A deficit in these advanced competencies generates a substantial risk of pedagogical reductionism. This phenomenon involves the reduction of multidimensional processes of cognitive development and critical judgment to quantifiable metrics discernible by the system, such as response velocity or login frequency (Bond *et al*., 2024, p. 20). Furthermore, professional development must address the psychological readiness of educators to operate within an "algorithmic world".

2.5. Ethical Implications of Al Integration in Higher Education

While systems based on generative models and machine learning promise radical personalization of learning and administrative optimization, they simultaneously redefine fundamental concepts of academic integrity, social justice, and pedagogical autonomy. The ethical dimension of this process is no longer merely a theoretical inquiry but a primary regulatory imperative, further underscored by the entry into force of the EU AI Act (2024), which classifies artificial intelligence systems in education as high-risk.

The central ethical conflict arises from the phenomenon of algorithmic bias. Artificial intelligence systems are not neutral entities, they function as "mirrors" of the datasets upon which they were trained. Bond *et al.* (2024, p. 21) confirm that algorithms trained on historically inequitable datasets do not merely reproduce but effectively automate social inequalities. Within the context of higher education, the application of predictive analytics for the early detection of academic risk may inadvertently penalize students from underprivileged socioeconomic backgrounds. If historical data reflects systemic injustice, algorithms transform such bias into deterministic prediction, thereby creating the risk of digital "ghettoization" of students.

Another significant challenge is the opacity of algorithmic decision-making, conceptualized as the "black box" problem. When a deep learning system renders a determination regarding the evaluation of student work or the allocation of scholarships, the underlying process of reaching that outcome often remains inaccessible to human comprehension. In response to this challenge, scholars strongly advocate for the implementation of Explainable AI (XAI) (Dwivedi, 2023, p. 42). XAI is no longer merely a technical preference but an ethical imperative that ensures the "right to an explanation".

The implementation of affective computing systems presents a distinct ethical challenge. While aforementioned studies highlight the high precision of deep learning models

in detecting cognitive fatigue and frustration through machine vision, others (Andrejevic & Selwyn, 2020) warn of the risk of transforming the classroom into a space of continuous biometric surveillance. The central issue lies in the quantification of subjective states into measurable metadata, systems analyzing facial micro-expressions, pupil dilation, or head movements de facto establish a regime of emotional control. Should students internalize the realization that every subconscious reaction is classified as "lack of engagement" or "boredom", there arises a risk of a process wherein students modify their natural behavior and simulate attentiveness to satisfy the system's algorithmic metrics. Consequently, the ethical imperative dictates a shift toward data minimization (EDPB, 2020, para. 73). Instead of invasive facial tracking, contemporary strategies advocate for the analysis of interaction with instructional materials without storing biometric identifiers. Institutions are obligated to ensure full transparency regarding data collection processes and guarantee students the right to opt-out of surveillance systems without academic repercussions.

Furthermore, the protection of data privacy within the new digital order acquires renewed legal significance with the entry into force of the EU AI Act (2024). Institutions are duty-bound to ensure that students' "digital footprints" are not utilized for commercial exploitation or model training without explicit informed consent. The issue of "data colonialism", analyzed by contemporary critics of digitalization (Mejias & Couldry, 2024, p. 116), warns of the danger of converting the educational process into a data reservoir for private corporations. Therefore, it is recommended to utilize exclusively licensed systems under institutional accounts (KU Leuven, General Guidelines, 2026).

3. COMPARATIVE ANALYSIS OF LEADING EUROPEAN MODELS OF AI INTEGRATION IN HIGHER EDUCATION

To operationalize the proposed conceptual framework, this section examines leading national models that demonstrate successful AI integration within the higher education landscape. The selection of these cases is not arbitrary, rather, it reflects a deliberate focus on European countries where digital transformation is supported by robust regulatory frameworks and innovative pedagogical standards. Corresponding to the domains analyzed in the previous chapter, a specific leading country was chosen to illustrate best practices in each area.

In 2021, the Finnish Ministry of Education and Culture initiated the implementation of the Digivisio 2030 program, encompassing all higher education institutions (DIGIVISIO). Beyond the enhancement of digital infrastructure and the deployment of e-learning instruments, Finland has pioneered the most systematic development of Data-Driven Pedagogy. This approach facilitates the real-time adaptation of instruction to meet the actual needs of students, predicated upon the systematic collection, analysis, and interpretation of digital footprints generated within Learning Management Systems (Dixon, Howe & Richter, 2025, pp. 5–6).

The methodological framework of this approach is based on multimodal data collection, categorized into three pivotal dimensions: the temporal (access times and session duration), the interactional (participation in forums and collaborative tools), and the performative (results of quizzes and automated assessments). The foundation of data processing is predictive modeling, a statistical technique utilizing historical datasets and machine learning algorithms to forecast, with a specific degree of probability, future student outcomes or behaviors (Ouatik

et al., 2022, p. 24). Researchers at the University of Turku developed the ViLLE platform, which utilizes an immediate feedback loop methodology: predicated on real-time error data, students are offered alternative resources, thereby realizing a personalized learning trajectory. These data function as a diagnostic instrument, directing educators toward curriculum segments perceived by students as most demanding, and enabling the dynamic adjustment of learning design (VILLE).

Furthermore, within the professional literature examining the intersection of AI and learning analytics in higher education, the United Kingdom has emerged as one of the preeminent European states. British practice transforms traditional learning analytics into a proactive support system (Herodotou *et al.*, 2019, p. 6). Rather than merely measuring engagement, these systems conduct in-depth linguistic processing of student interactions, thereby achieving insights into the quality of argumentation, the level of critical thinking, and the development of conceptual understanding. By identifying specific linguistic patterns, AI instruments can isolate precise points where impediments occur in the knowledge acquisition process.

This analytical framework enables educational institutions to transition from descriptive analytics ("what the student does") to predictive and prescriptive analytics that address internal cognitive processes. A significant shift has also been achieved regarding the biopolitical surveillance of students, moving toward so-called human-centered analytics. Instead of penalizing students who do not adhere to a linear trajectory, these systems are designed to recognize diverse learning styles and cognitive profiles. This approach avoids the creation of a "digital panopticon", wherein students exhibit performative behavior rather than focusing on the authentic acquisition of knowledge.

The authors highlight Germany as a good example of the integration of automated short answer grading systems. The German model is predicated upon high linguistic precision, evaluating not merely keywords but also the semantic accuracy and logical structure of student responses. Pado, Eryilmaz, & Kirschner (2023, pp. 1324–1326) analyze the implementation of response triage systems within large-scale examination frameworks, where AI automatically processes clear cases while escalating borderline or complex cases to a human examiner for verification. Significant focus is placed on the FORMAT project (2022–2026), directed toward the development of adaptive feedback that provides students with qualitative explanations, consequently, the system functions as a tool for formative learning support rather than solely for summative grading (Formative Writing Assessment, 2022-2026). Furthermore, substantial emphasis is placed on the prevention of algorithmic discrimination based on writing style or dialect. Models are trained to evaluate substantive accuracy rather than linguistic aesthetics, thereby ensuring equal opportunities for students with diverse backgrounds and linguistic styles, including non-native speakers of German.

Furthermore, Estonia distinguishes itself as a vanguard in the integration of AI across all levels of the pedagogical process, particularly through its investment in the massive upskilling of faculty. In September 2025, a training initiative for 3,000 educators commenced, with a projected expansion to 5,000 by the spring of 2027 (Euridyce). Implementation is primarily conducted through specialized micro-credential modules and institutional centers for digital didactics, such as those at Tallinn University and TalTech, which enable faculty to acquire formally recognized ECTS credits in the field of AI competencies. The educational process is structured into five units encompassing technical-operational proficiency, pedagogical integration, research application, critical content evaluation, and the ethical-legal framework

(Lepik-Verliin, Hint & Leijen, 2025, pp. 20–22). Particular emphasis is placed on developing skills for the validation of machine-generated data to prevent disinformation and cognitive bias.

Finally, the ethical regulation of AI within the Norwegian higher education represents a model founded upon a high degree of institutional autonomy aligned with national and supranational ethical frameworks. Guidelines from the leading universities in Oslo and Bergen explicitly mandate that AI instruments must be treated exclusively as auxiliary aids that shall not compromise the independence and critical scope of student work (Vold & Eikset, 2024). The first pillar of this practice is methodological transparency, which requires that every interaction with AI systems be precisely documented, thereby ensuring the traceability of the learning process and preventing the non-transparent generation of academic content. The second pillar concerns rigid data protection in accordance with GDPR provisions, with a specific focus on the development of secure institutional digital environments that minimize the risks of unauthorized exploitation of student data. Furthermore, algorithmic accountability entails the systematic education of faculty to identify biases and systemic "hallucinations", thereby mitigating the risk of disseminating disinformation within scholarly and instructional discourse. The issue of academic integrity in Norway is being redefined through the prism of AI literacy, where the emphasis shifts from the detection of unauthorized use toward the transformation of assessment methodologies. The objective is the evaluation of the knowledge acquisition process rather than an exclusive focus on the final examination, consequently, ethical responsibility is equitably distributed between students, who are obliged to practice fair citation, and institutions, which must ensure equitable and credible evaluative conditions (Wahid, 2024, pp. 49–51).

4. ANALYSIS OF AI REGULATION AND APPLICATION IN THE CROATIAN HIGHER EDUCATION SYSTEM

The European Union initiated the regulation of the field of artificial intelligence in 2018 with the adoption of the inaugural Ethics Guidelines for Trustworthy AI. This was subsequently followed by the Coordinated Plan on Artificial Intelligence of 2018 (revised in 2021) and the White Paper on Artificial Intelligence, which was developed upon the foundations of the aforementioned Plan (Dujmović Bocka, Romić & Vajda Halak, 2024, pp. 809–810). The primary legislative instrument in this domain is Regulation (EU) 2024/1689 of 13 June 2024, which aims, inter alia, to promote the deployment of trustworthy artificial intelligence within the European Union as part of a broader package of measures designed to enhance security, the fundamental rights of users, and innovation in AI utilization (Artificial Intelligence Act). Full implementation of the Act necessitates the adaptation of national legislation.

In the context of Croatia, the Ministry of Justice, Public Administration, and Digital Transformation assumed the obligation in 2025 to draft the National Plan for the Development of Artificial Intelligence for the period until 2032, along with the accompanying Action Plan for Implementation for the 2026–2028 period. Regarding strategic documents, the Digital Croatia Strategy for the period until 2032 anticipates the pervasive utilization of advanced technologies, such as 5G/6G, AI, machine learning, cloud computing, Big Data, and blockchain, within both the public and private sectors over the next decade. Furthermore, it is subsequently emphasized that the application of these emerging technologies will place particular

importance on fostering cooperation between the academic community and the private and public sectors, aimed at achieving a synergy of knowledge, human capital, regulatory frameworks, and financial resources.

Naturally, universities and HEIs also adopt strategic documents in this field autonomously, albeit in alignment with European and national priorities. The research conducted by the authors encompassed ten public and four private Croatian universities: Public universities in Dubrovnik, Koprivnica, Osijek, Pula, Rijeka, Slavonski Brod, Split, Zadar, and Zagreb, as well as the private universities Algebra, Libertas, Vern, and the Catholic University of Croatia. Only two public (University of Rijeka in 2024, and University of Zadar in 2026) and one private university (Algebra University in 2025) have adopted formal policies or guidelines for the responsible use of AI within the educational process. Additionally, eight public higher education institutions adopted such guidelines between April 2024 and January 2026: Faculty of Economics and Faculty of Humanities and Social Sciences in Osijek; Faculty of Health Sciences and Faculty of Humanities and Social Sciences in Split; Faculty of Electrical Engineering and Computing, Faculty of Organization and Informatics, Faculty of Food Technology and Biotechnology, and Faculty of Teacher Education in Zagreb. Through the analysis of these guidelines and policies, the authors identified certain pillars constituting a coherent framework for the preservation of academic integrity while simultaneously fostering innovation. Given that these pillars are common to all analyzed documents, it is considered essential to address them in further detail.

The first pillar is transparency and a rigorous citation obligation, considered the most critical rule within the instructional process; it mandates that students provide mandatory and precise attribution for every form of machine assistance, including the specification of the tool utilized, its version, and a detailed explanation of the purpose of its use. While technical faculties frequently require the inclusion of the utilized commands (prompts) to provide insight into the generation of programming code, institutions in the social sciences and humanities emphasize formal declarations within the preface or footnotes of the assignment.

Secondly, notwithstanding the technological advancement of generative models, the academic community insists upon the exclusive personal responsibility of the student and the obligation of critical fact-checking, given that AI is defined solely as a tool rather than an author or a relevant source. In the technical sciences, this verification involves the validation of algorithmic accuracy and code optimization, whereas in the social sciences, emphasis is placed on verifying cited references and mitigating "hallucinations" in the interpretation of theoretical frameworks. The strict prohibition of the direct reproduction of machine-generated content remains universal, consequently, generating entire essays or completing examinations without substantive human intervention is classified as a severe violation of academic integrity.

Thirdly, the implementation of these technologies is further contingent upon the specific regulations established by course coordinators, whose autonomy remains decisive in defining the boundaries of permissible use within individual learning processes. While faculty at technical colleges more frequently integrate AI as a mandatory instrument for resolving complex engineering problems, a more cautious approach prevails in the humanities, aimed at safeguarding critical writing and analytical skills. Nevertheless, all systems provide for the possibility of oral defenses of assignments to verify the authentic comprehension of the subject matter. Finally, the ethical framework encompasses the imperative of data privacy protection. Guidelines strictly prohibit the input of data that could reveal an individual's

identity or confidential information, including personal data, classified documents, and non-anonymized research results. Such approaches ensure that technological integration serves to augment, rather than substitute, human cognitive contribution.

The guidelines also delineate the specific domains in which HEI may apply AI. These areas are common to all analyzed faculties and universities, encompassing the use of AI in instruction, the drafting of student assignments, scientific research, and administrative functions. For educators, these tools may facilitate lecture preparation, the creation of personalized instructional materials, and the development of adaptive assessments that provide students with rapid evaluation during the learning process, thereby accelerating the grading cycle. Permissible applications in assessment include the automated grading of objective questions (e.g., multiple-choice, true/false, short answers) and the preliminary evaluation of programming tasks, where AI may assess syntactic correctness and code structure, though not conceptual understanding or the logic of the solution. Regarding the drafting of assignments, students are permitted to utilize tools for linguistic and stylistic refinement, assistance in conceptualizing the work's structure, and technical support in sourcing references, in accordance with the educator's instructions. In scientific research, the utilization of these instruments is permitted for identifying potential research questions, expediting the retrieval of relevant sources, proofreading, grammatical verification, stylistic improvement, and translation. Finally, the application of tools in administrative functions pertains to the preparation of notes, meeting minutes, analytical documents, or reports.

5. AI INTEGRATION IN CROATIAN UNIVERSITIES: KEY RECOMMENDATIONS

Following the analysis of the Croatian framework and European best practices, it is possible to formulate recommendations for the enhancement of AI regulation and application within the Croatian academic environment. A fundamental deficiency is the significant regulatory deficit concerning AI utilization in higher education. Only three public universities and eight faculties have adopted strategic documents. While a complete absence of positive practices cannot be established, the primary recommendation pertains to the necessity of intensifying institutional efforts toward the prompt adoption of strategic documents, given that the development and integration of AI into global educational processes are in an advanced stage.

In the domain of pedagogical innovation, student-centered learning and various e-learning methods have been applied at Croatian universities for over a decade. However, it is imperative that Croatia begins implementing more advanced learning analytics. The authors recommend the integration of pedagogical approaches based on data analytics, specifically, the implementation of systems for the real-time analysis of digital footprints, which will facilitate further personalization of the instructional process through instantaneous feedback and data-driven teaching adjustments. Another significant measure in the field of learning process involves the transition from descriptive to predictive analytics. Predictive modeling is crucial for the early identification of cognitive impediments, thereby contributing to the prevention of academic failure.

Regarding the automation of assessment and grading, automated short answer grading has been implemented. However, a third recommendation in this domain is directed toward the development of adaptive feedback that provides students with qualitative explanations of assigned grades, thereby transforming the AI system into a tool for formative learning support rather than solely for summative grading.

A fundamental prerequisite for the successful integration of AI is the existence of educated faculty and students. Therefore, the fourth recommendation, within the domain of digital skills development, pertains to the strengthening of AI literacy. It is necessary to initiate a national program for massive faculty education which, beyond the operational application of AI tools, would encompass the critical evaluation of machine-generated data and the ethical-legal framework. Concurrently, students should be educated in AI literacy, moving away from an approach oriented exclusively toward the detection of unauthorized tool utilization.

Finally, to strengthen the ethical dimension of AI usage, the authors recommend mandating the disclosure of the specific tool models used and the systematic inclusion of utilized prompts in all forms of student assignments across all faculties. Such a practice would ensure: (a) the complete traceability of the cognitive learning process, providing educators with insight into how the student structured the problem and arrived at a solution using AI, (b) the prevention of non-transparent content generation and the uncritical adoption of machine-generated dana, and (c) a clear distinction between the tool's contribution and the student's original authorship, thereby strengthening trust in the outcomes of the educational process and ensuring the objective evaluation of acquired competencies.

To provide a comprehensive overview of the research findings, the following table synthesizes the identified domains of AI implementation, the corresponding best practices from European states, and the resulting recommendations tailored for the Croatian higher education system.

DOMAIN	BEST PRACTICE	RECCOMENDATION
Pedagogical innovations	Data-driven pedagogy and student knowledge modeling algorithms, Finland	Adoption of strategic documents concerning AI tool integration aimed at fostering pedagogical innovations (especially human-in-the-loop concept)
Learning analytics	Predictive modeling based on "digital footprints", UK	Implementation of systems for the real-time analysis of "digital footprints"
Automated assessment and grading	Response triage system and adaptive feedback, Germany	Development of adaptive feedback that provides students with qualitative explanations of assigned grades
Digital literacy	Massive upskilling od academic staff, Estonia	Conduct a national program to enhance AI literacy among faculty and students
Ethical standards	Ethical responsibilities distributed between students and institutions, Norway	Establish a mandatory disclosure of the AI model and the systematic submission of all utilized prompts

Source: Prepared by the authors based on research findings

6. CONCLUSION

Contemporary higher education is undergoing a phase of radical digital transformation driven by the exponential development of AI. This technological momentum not only redefines administrative processes but fundamentally transforms pedagogical paradigms, research methodologies, and the nature of interaction between educators and students. Given that the integration of generative and analytical AI tools into global academic workflows is already in an advanced stage, a systematic adaptation of educational policies is essential to ensure the cognitive evolution of students while preserving the highest ethical standards.

The digital transformation of higher education in Croatia has commenced but remains in an early and fragmented stage (Dobrić Jambrović, 2026). The primary cause is the sparse regulation of AI utilization at both national and HEI levels. Out of a total of eleven universities, only three have drafted usage guidelines. At the faculty level, the situation is even more critical: of 73 public faculties, only eight have developed strategic documents. Consequently, a key segment of this study encompasses a comparative evaluation of leading European practices to determine the feasibility of their application within the Croatian higher education.

The research was based on a previously elaborated theoretical framework covering five domains of AI implementation: pedagogical innovations and student-centered learning, learning analytics and predictive modeling, automation of student assessment and grading, AI literacy for faculty and students, and the ethical domain. For each domain, one state was identified as a best-practice example, respectively: Finland, the United Kingdom, Germany, Estonia, and Norway. By analyzing these international systems, the authors identified measures that Croatia could implement to enhance the utilization of AI tools.

The key recommendations pertain to: a) the necessary systematic and coherent regulation of AI at the university and faculty levels, b) the implementation of pedagogical approaches based on learning analytics that enable real-time adaptive instruction, c) the introduction of automated formative assessment, d) the strengthening of AI literacy among teaching staff and students, and e) the mandatory disclosure of utilized tool models and the systematic inclusion of prompts in all forms of student assignments. In conclusion, enhancing the application of AI systems in Croatian higher education requires a holistic approach focused on the strategic development of educational policies and the systematic integration of advanced pedagogical and technological models.

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