Transforming Higher Education with AI: A Cognitive Infocommunications Perspective

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***Abstract*—. Artificial Intelligence (AI) is increasingly becoming crucial in transforming higher education, offering potential benefits such as personalized learning experiences, predictive analytics, and improved administrative efficiency. However, the implementation of AI also presents significant challenges, including regulatory compliance, ethical considerations, and the need for robust technical infrastructure. This paper explores the regulatory framework governing AI in education and further presents practical applications of AI, such as reducing dropout rates, predictive analysis for admissions, and curriculum network analysis. Additionally, the paper examines the AI effect in higher education from a Cognitive Infocommunications perspective. Emphasizing the scope of human-ICT coevolution, the paper highlights how AI-driven tools can encourage a synergistic relationship between human cognition and information and communication technologies (ICT), enhancing educational outcomes while addressing regulatory and ethical concerns. The aim is to provide a comprehensive overview of the potential and challenges of integrating AI in higher education, offering insights for policymakers, educators, and technologists.**

Keywords—CogInfoCom; AI, human-computer coevolution

I. INTRODUCTION

The advent of Artificial Intelligence (AI) has opened new frontiers in various sectors, and higher education is one of them. AI can handle huge amounts of data and provide useful insights, making it possible to transform how education works. It can predict how students will perform and create personalized learning experiences to meet individual needs. However, bringing AI into schools and universities comes with challenges. These include dealing with regulations, ethical concerns, and the need for significant technical and infrastructure investments.

The advancements in AI and its application in higher education align closely with the objectives of Cognitive Infocommunications (CogInfoCom) [1, 2], a research field focused on the integration and coevolution of human cognitive capabilities and information and communication technologies (ICT). CogInfoCom aims to enhance the symbiotic relationship between humans and ICT, making interactions more intuitive and effective. AI's ability to process vast amounts of data and provide personalized insights directly supports this goal by creating more adaptive and responsive educational environments.

Furthermore, the integration of AI into higher education represents a significant step in human-ICT coevolution. This concept involves the continuous and mutually beneficial development of human capabilities and technological advancements. By leveraging AI, educational institutions can create learning systems that not only respond to individual student needs but also evolve based on user interactions and feedback, fostering an environment where human cognitive processes and ICT tools grow together. This coevolutionary approach can enhance learning experiences and prepare students for a future where AI and other disruptive technologies play a central role in daily life.

This paper aims to provide a detailed examination of the potential and challenges associated with implementing AI in higher education.

The paper structure is as follows:

The second section outlines the regulatory landscape governing the use of AI in education. It focuses on EU regulations, particularly the AI Act, and Hungarian national policies. Additionally, it examines stringent university policies to illustrate the diversity in regulatory approaches.

In the third section, the author presents the AI effects in higher education from Cognitive Infocommunications perspective, after then practical applications of AI in higher education. These include strategies for reducing dropout rates, using Bayesian methods for predictive analysis of admission scores, student progress prediction, course completion analysis, and curriculum network analysis. Each of these applications demonstrates how AI can contribute to more efficient and effective educational processes.

The fourth section presents various practical applications of AI in Higher Education, demonstrating its potential to improve educational processes. It includes strategies to mitigate student dropout rates, predictive analysis for admissions, student

progress prediction, course completion analysis, and curriculum network analysis.

The fifth section examines how AI can enhance the learning process. It highlights opportunities for personalized learning assistants and AI-supported teaching, which can create more engaging and tailored educational experiences. Moreover, we emphasize the importance of prompt engineering education [3, 4], which equips both educators and students with the skills necessary to harness AI tools effectively.

By providing a comprehensive overview of these aspects, this paper seeks to offer valuable insights and guidance for policymakers, educators, and technologists navigating the complexities of integrating AI into higher education. Through a balanced discussion of the potential benefits and challenges, we aim to foster a deeper understanding of how AI can be leveraged to enhance educational outcomes while addressing the accompanying regulatory and ethical concerns.

II. Regulatory Framework

A. EU Regulations on AI in Education [5-7]

The EU has established comprehensive regulations to manage the development and deployment of AI systems through the Artificial Intelligence Act (AI Act) [5]. The AI Act, finalized in early 2024, introduces a risk-based approach to classify AI systems, focusing on ensuring accuracy, robustness, and cybersecurity throughout the AI system's lifecycle [5]. The AI Act aims to regulate AI systems based on a risk classification system. It categorizes AI applications into four risk levels: unacceptable, high, limited, and minimal risk. Unacceptable risk AI systems are banned, while high-risk systems must comply with stringent requirements related to data quality, transparency, human oversight, and accountability. Limited and minimal risk systems face lighter obligations, primarily focusing on transparency [5, 6]. High-risk AI systems, including those used in education, are subject to stringent requirements to ensure they do not pose significant risks to health, safety, or fundamental rights. Key provisions include mandatory transparency obligations, human oversight measures, and robust logging capabilities to ensure traceability and explainability of AI operations. The AI Act also requires that AI systems interacting directly with individuals, such as educational tools, inform users that they are engaging with an AI system and disclose any synthetic content generated by these systems [6, 7].

The AI Act established the European Artificial Intelligence Board to oversee the uniform application of the regulation across the EU. This body will issue guidelines, opinions, and recommendations on AI regulation issues. Additionally, high-risk AI systems must undergo a conformity assessment and be registered in an EU database before market deployment [5, 8].

The EU had also established a Coordinated Plan on AI to foster AI excellence, which includes setting up networks of AI excellence centers, digital innovation hubs, and public-private partnerships. This plan aims to support the safe and innovative use of AI across various sectors, including education [9].

These regulations are designed to create a balanced environment where AI technologies can develop while protecting users' rights and maintaining high ethical standards in their deployment.

B. Hungarian Regulations on AI

Hungary's approach to AI regulation is closely aligned with the broader EU framework, particularly the EU's Artificial Intelligence Act (AI Act) [5]. However, Hungary has also developed its national AI strategy to address specific national priorities and challenges. Covering the period from 2020 to 2030, Hungary's National AI Strategy [10] emphasizes integrating AI across various sectors, including education, healthcare, agriculture, and public administration. A key pillar of this strategy is education and competency development, aiming to raise public interest in AI, highlight its benefits and risks, and prepare society for its adoption [10]. This involves educating users about AI technologies and fostering an "early adopter" mindset while enhancing critical thinking skills.

Compliance with the General Data Protection Regulation (GDPR) [11] is a cornerstone of Hungary's AI regulatory framework, ensuring transparency, user consent, and the secure handling of personal data. AI systems, especially high-risk ones, must include human oversight to maintain accountability and trust. The Hungarian government also supports creating testing environments for AI technologies to address regulatory issues before full-scale deployment.

In education, AI is used to develop personalized learning paths and career advisory systems to enhance individual competencies in a rapidly changing job market. Hungary fosters AI research and innovation through initiatives like the National Artificial Intelligence Laboratory (MILAB) [13], aiming to enhance its global competitive position and encourage collaboration between academia, industry, and government bodies.

C. University Policies on AI

There are different ways universities handle AI use, from detailed guidelines to strict bans, aiming to balance innovation with ethical and academic standards. Universities are creating specific rules to manage how artificial intelligence (AI) is used, addressing ethical, academic, and security concerns [12]. Some Universities require, that all instructors should update their syllabi to include guidance on the use of generative AI in their classes. Many of them encourage lecturers to try at least one generative AI tool and keep an open and curious mindset when considering whether such tools could be helpful to some or all of their students [9]. At the same time some schools, like Salem State University, do not allow AI use in certain courses and consider AI-generated work as plagiarism. This strict rule is used in classes that focus on writing and critical thinking skills.

In the age of AI transformation leading Hungarian universities like Corvinus University of Budapest, Eötvös Loránd University (ELTE), and Budapest University of Technology and Economics (BME), etc. are actively integrating AI into their academic and research frameworks,

aligning with national and international AI strategies. These Universities established several initiatives to incorporate AI into their educational and research activities, such as hosting workshops and conferences, promoting the latest advancements in AI and related technologies, and integrating AI into various study programs.

III. The AI Effect in Higher Education: A Cognitive Infocommunications Perspective

The integration of Artificial Intelligence (AI) in higher education brings about significant changes, often described as the AI effect [14, 15]. This phenomenon includes several important aspects from a Cognitive Infocommunications (CogInfoCom) [1, 2] perspective, directly impacting the coevolution of human-ICT. The selected points illustrate key dimensions of this impact and provide a comprehensive overview of how AI influences higher education.

The nine points selected—Memory vs. Skills, Cognitive Adjustment, Technological Reliance, Perception Shift, Dependency and Skills Redistribution, Critical Thinking, Ethical Considerations, Emotional and Social Learning, and Lifelong Learning and Skill Development—represent critical areas where AI significantly interacts with human cognitive and functional capabilities. These points were chosen based on their relevance to both the educational process and the broader implications of AI integration. While these points cover significant aspects, they are not exhaustive; the field is continuously evolving, and other relevant factors may emerge.

Memory vs. Skills:

The Google effect [16, 17] primarily concerns the outsourcing of memory and information retrieval to technology. The AI effect, on the other hand, impacts a broader range of cognitive and physical skills, delegating many routine tasks to AI systems while emphasizing human abilities like creativity and emotional intelligence. This distinction highlights the shift from memory-based learning to skill-based learning, necessitating a change in educational focus.

Cognitive Adjustment:

AI effects [14, 15] demonstrate cognitive adjustments where humans adapt to the strengths of these technologies and judge machines by their outcomes [23]. Initially, classical Internet searching was about efficient information retrieval. With AI, the focus has shifted to enhancing decision-making processes and task execution, reflecting a deeper integration of AI in cognitive tasks.

Technological Reliance:

Increased reliance on AI tools and the internet can lead to a decrease in the development of certain skills. However, it can also enhance other skills, particularly in managing and interacting with these technologies. This highlights the importance of teaching students how to effectively use AI tools while also developing their critical thinking and problem-solving abilities.

Perception Shift:

The perception shift in AI refers to the changing boundaries of what is considered artificial intelligence. Initially, tasks such as speech recognition or automated grading systems are seen as hallmarks of AI. However, as these technologies become routine and widely accepted, they are no longer perceived as AI but as standard automated processes. This shifting boundary can make advancements in AI seem less impressive over time, even though they continue to evolve and improve. For higher education, this means continually redefining the curriculum to include the latest AI capabilities, ensuring that students are aware of and proficient in the newest technologies.

Dependency and Skills Redistribution

Similar to the Google effect [16, 17], where reliance on search engines alters our memory habits, the AI effect [14, 15] involves a redistribution of skills. As AI systems handle tasks such as data analysis, administrative work, and even elements of teaching, students and educators might focus less on these areas and more on skills that AI cannot easily replicate. This includes creative thinking, emotional intelligence, and interpersonal skills. In higher education, this necessitates a shift in teaching methodologies to emphasize these human skills, preparing students for a future where AI handles routine tasks.

Critical thinking:

There is a fluctuating relationship between trust and skepticism regarding AI. As AI becomes more embedded in everyday academic life—through tools like automated grading, virtual assistants, and personalized learning systems—users may develop greater trust in its capabilities for certain tasks. However, this trust is tempered by skepticism, especially concerning AI's failings and biases. Ensuring that students and faculty understand the strengths and limitations of AI is crucial. This involves teaching critical thinking skills and ethical considerations surrounding AI use [22], which are integral components of a CogInfoCom-oriented curriculum.

Ethical Considerations:

AI in education raises numerous ethical issues, including data privacy, bias in AI algorithms, and the potential for unequal access to AI-enhanced educational resources. Addressing these ethical concerns is crucial to ensure that AI applications are fair and beneficial for all students. Educational institutions need to establish guidelines and policies to manage these ethical issues effectively.

Emotional and Social Learning:

AI can also impact emotional and social learning by providing tools that support emotional intelligence development and social interactions. For example, AI-driven platforms can offer personalized feedback on students' social behaviors and emotional responses, helping them develop better interpersonal skills. Integrating AI tools that focus on these aspects can enhance students' overall learning experience and personal growth.

Lifelong Learning and Skill Development:

AI can support lifelong learning by offering personalized learning experiences that adapt to the evolving needs of learners at different stages of their careers. This aspect is particularly important in a rapidly changing job market where continuous skill development is essential. AI can help identify skill gaps and recommend targeted learning resources to address them, thereby facilitating ongoing professional development.

CogInfoCom-Oriented Curriculum:

The AI effect in higher education, viewed through the aspects of Cognitive Infocommunications, highlights the dynamic interaction between humans and technology. As AI continues to evolve, educational institutions must adapt by reshaping curricula to balance the development of technical proficiency and uniquely human skills. Through this balanced integration, higher education can enhance learning outcomes and support the coevolution of human and ICT capabilities.

These points collectively provide a comprehensive framework for understanding the multifaceted impact of AI in higher education. They highlight areas where AI introduces significant changes and underscore the need for educational strategies that accommodate these shifts. While these points cover critical aspects, the dynamic nature of AI integration means that additional factors may become relevant as the technology and its applications continue to evolve.

IV. Practical Applications of AI in Higher Education

AI has the potential to significantly enhance various aspects of higher education. Here are some practical applications:

1. Predictive Analysis for Admission Scores:

Using Bayesian methods [24, 25], AI can predict the risk of students dropping out based on their admission scores and other factors such as high school Grade Point Average (GPA) and socioeconomic status (SES). This approach improves the efficiency of the admissions process by helping universities select candidates who are more likely to succeed.

Bayesian methods [24, 25] involve updating the probability estimate for a hypothesis as more evidence or information becomes available. Let's consider a university predicting the likelihood of students dropping out.

- Prior Probability (P(H)):
  The university starts with prior knowledge that historically, 10% of students drop out before completing their degree. So, the prior probability of dropping out (H) is:
  $$P(H) = 0.10$$
- Likelihood (P(D|H)):
  Data shows that among students who dropped out, 70% had admission scores in the lower quartile. Therefore, the likelihood (P(D|H)) of having low admission scores given that a student drops out is:
  $$P(D|H) = 0.70$$
- Marginal Likelihood (P(D)):
  Across all students, 25% have admission scores in the lower quartile. This is the probability of a student having a low admission score regardless of dropout status.
  $$P(D) = 0.25$$
- Posterior Probability (P(H|D)):
  Using Bayes' Theorem, the university updates the probability of a student dropping out given that they have low admission scores:
  $$P(H|D) = \frac{P(D|H) \cdot P(H)}{P(D)}$$
  Substituting the values:
  $$P(H|D) = \frac{0.70 \cdot 0.10}{0.25} = 0.28$$

Thus, the updated probability that a student with low admission scores will drop out is 28%.

This Bayesian approach allows the university to dynamically update the dropout risk as new data becomes available, such as mid-term grades or engagement metrics. By identifying students at higher risk of dropping out, the university can provide targeted interventions to support these students.

The use of Bayesian methods in predictive analysis for admission scores exemplifies how AI can enhance decision-making processes, a key aspect of cognitive adjustment as described in section III.

A. Student Progress Prediction

AI tools can monitor student performance in real-time, providing insights into their progress and identifying areas where they may need additional support. This enables timely interventions and helps students achieve better outcomes.

Most universities use an online learning platform like Coursera, Moodle, or edX and some use VR educational spaces that offer courses in various subjects. If the platform integrates AI tools to monitor student performance in real-time, then can providing insights into their progress and identifying areas where they may need additional support. Here AI can support the Data Collection.

- Interaction Data: The platform collects data on how students interact with the course materials. This includes time spent on videos, participation in discussion forums, completion of quizzes and assignments, and patterns of accessing supplementary resources.
- Performance Data: The AI system follows students' performance on projects, quizzes, assignments, and exams, noting both correct and incorrect responses [21].
- Identification of Behavioral Patterns: The AI system can detect behavioral patterns, such as procrastination (e.g., if a student tends to cram before deadlines) or engagement (e.g., regular participation in discussions).

Real-time monitoring of student performance aligns with the AI effect on technological trust, as it enhances skills in managing and interacting with these technologies, thus supporting human-ICT coevolution.

B. Learning process support

- Insights and Alerts: Personalized Feedback: Based on the analysis, the AI system provides real-time feedback to students. For example, if a student consistently struggles with a particular type of question, the system might suggest additional practice problems or recommend specific readings.
- Alerts to Instructors: The AI tool alerts instructors to students who are at risk of falling behind. For instance, if a student fails to complete several consecutive assignments or shows a sudden drop in performance, the system notifies the instructor to intervene.
- Personalized Learning Assistants: AI-powered personal assistants can provide personalized support to students, helping them with study schedules, answering questions, and offering resources based on their individual needs and preferences [20]. This personalized approach can improve student engagement and learning outcomes.
- Adaptive Learning Paths and Contents: The platform may adjust the learning path for students based on their needs. For instance, it might provide easier problems to build confidence or offer digital content that matches individual information acquisition preferences and learning styles [18, 19].

Personalized learning assistants highlight the perception shift in AI, where initially advanced AI capabilities become routine tools that continuously improve and evolve, emphasizing the need for updated curricula to keep students proficient in new technologies.

C. Course Completion Analysis

- Real-Time Analysis for Progress Tracking: AI algorithms analyze the collected data to create a detailed profile of each student's progress. For instance, it identifies which topics the student has mastered and which ones they are struggling with.
- AI can analyze data on course completion rates to identify factors that contribute to student success or failure. This information can be used to improve course design and delivery, enhancing the overall learning experience.

Course completion analysis reflects the AI effect on skills redistribution, where AI handles routine tasks, allowing educators and students to focus on more complex, creative, and interpersonal skills.

D. AI-Supported Teaching administration

- Automating administration: AI can assist educators by automating administrative tasks, grading assignments, and providing insights into student performance. This allows teachers to focus more on instruction and interaction with students, improving the overall quality of education.

Automating administrative tasks aligns with the technological reliance aspect of the AI effect, illustrating how AI can enhance human cognitive capabilities by managing routine tasks and allowing for greater focus on complex interactions.

E. Curriculum Network Analysis

AI can map the relationships between different courses and programs, helping universities optimize their curricula. This analysis can reveal gaps or overlaps in content, enabling institutions to offer more coherent and comprehensive educational programs.

One practical example of this is Carnegie Learning's MATHia, an AI-driven tutoring system [22] used in middle and high schools. MATHia uses AI to:

- Track student interactions with math problems.
- Provide real-time feedback on student performance.
- Adjust the difficulty of problems based on student progress.
- Notify teachers of students who need additional help, allowing for timely interventions.

By leveraging these AI applications, higher education institutions can create more efficient, effective, and personalized learning environments, ultimately enhancing educational outcomes and preparing students for the future.

Curriculum network analysis supports the perception shift in AI, demonstrating the evolving role of AI from performing isolated tasks to enabling comprehensive educational planning and optimization.

V. CONCLUSION

Through the lens of Cognitive Infocommunications (CogInfoCom), the paper examined the AI effect in higher education, emphasizing the importance of human-ICT coevolution. This coevolution involves the continuous and mutually beneficial development of human capabilities and technological advancements. By leveraging AI, educational institutions can create adaptive learning systems that evolve based on user interactions and feedback.

In conclusion, the integration of AI in higher education presents both opportunities and challenges. By understanding and addressing these through a Cognitive Infocommunications perspective, institutions can enhance learning outcomes and encourage a dynamic, coevolutionary relationship between human cognition and AI. This balanced integration of AI will support the continuous growth of both human and technological capabilities, ultimately enriching the educational landscape. This partnership with AI not only improves educational processes but also prepares students for a future where AI plays a central role in the corporate world.

While this paper explores the potential impact of AI in higher education, it is important to acknowledge several

limitations in the current research. First, the application of the methods presented is still in the pilot phase. As a result, the measurable benefits of AI applications, which can be verified through statistical methods, cannot yet be clearly stated. The expectations for these applications are promising, but empirical evidence is still lacking at this stage. Additionally, the current analysis is based on theoretical frameworks and preliminary data. The effectiveness of AI integration in educational settings can vary widely depending on numerous factors, including the specific technologies used, the implementation context, and the adaptability of both educators and students. The author plans to address these limitations by conducting a subsequent empirical study to provide a comparative analysis based on actual measurements.

By acknowledging these limitations, the author aims to provide a balanced perspective and emphasize the need for ongoing research and empirical validation to fully realize the potential of AI in transforming higher education.

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