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Attila Vinkó

Zsolt Vinkler

+381 (24) 624 444

magister.uns.ac.rs/conf

ict.conf@magister.uns.ac.rs

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# THE IMPACT OF ARTIFICIAL INTELLIGENCE ON THE EDUCATION SYSTEM

TÜNDE LENGYELNÉ MOLNÁR<sup>1</sup>, LAJOS TOLDI<sup>2</sup>

<sup>1</sup> Eszterházy Károly Catholic University, Eger, Hungary

<sup>2</sup> Obuda University, Budapest, Hungary

[lengyelne.tunde@uni-eszterhazy.hu](mailto:lengyelne.tunde@uni-eszterhazy.hu), [toldi.lajos@gmail.com](mailto:toldi.lajos@gmail.com)

## *Abstract*

The Fourth Industrial Revolution is drastically transforming how our world functions. It reshapes the technological environment, reforms economic operations, and brings about living conditions that alter the everyday lives of society. Consequently, the competencies required by the labor market are constantly evolving. New skills, such as the ability to analyze artificial intelligence and big data, are emerging, and jobs specializing in these areas are expected to increase by 30–35% (World Economic Forum, 2023). These developments pose a dual challenge for educational systems: on the one hand, they must prepare learners for the changing competency demands, and on the other, they need to identify the potential of AI in education development. The advancement of educational systems is entering a new dimension with natural language processing (NLP) and the application of large language models like ChatGPT. This may represent a paradigm shift in education, offering significant advantages while also presenting problems to solve and ethical concerns to address.

*Keywords: intelligent tutoring systems, large language models, artificial intelligence in education*

## **1. Introduction**

We are living in the era of the Fourth Industrial Revolution, and ten years after its inception, it is clear how profoundly it is transforming industry, work environments, homes, daily communication, administrative processes, and information acquisition channels. The ongoing Fourth Industrial Revolution has initiated a cultural paradigm shift, affecting the functioning of society (Kis-Tóth, Gulyás, Enikő & Racsko, 2017) and even prompting a redefinition of what society means. Several scholars describe this new type of living space as a cyber-physical society, characterizing the structured relationships of people adapting to this environment. "Cyber-physical approaches can lead to 'smart' cities, manufacturing, transportation, logistics, and energy systems, contributing to the creation of a new quality of life. In this regard, we can already talk about a cyber-physical society, which encompasses not only physical and cybernetic spaces but also human, social, and cultural spheres" (Monostori, 2016). According to Levin (2016), the cyber-physical system is a factor of technological culture, where we can speak of new residents of the digital society. Other researchers (Deguchi, Atsushi, et al., 2020; Fukuyama, 2018; Kravets, Bolshakov & Shcherbakov, 2022) conceptualize the changes as the emergence of Society 5.0, a new human-centered society. While the terminology varies, the underlying concept is the same: people must adapt to a new, technologically advanced environment, creating a form of symbiosis between humans and machines.

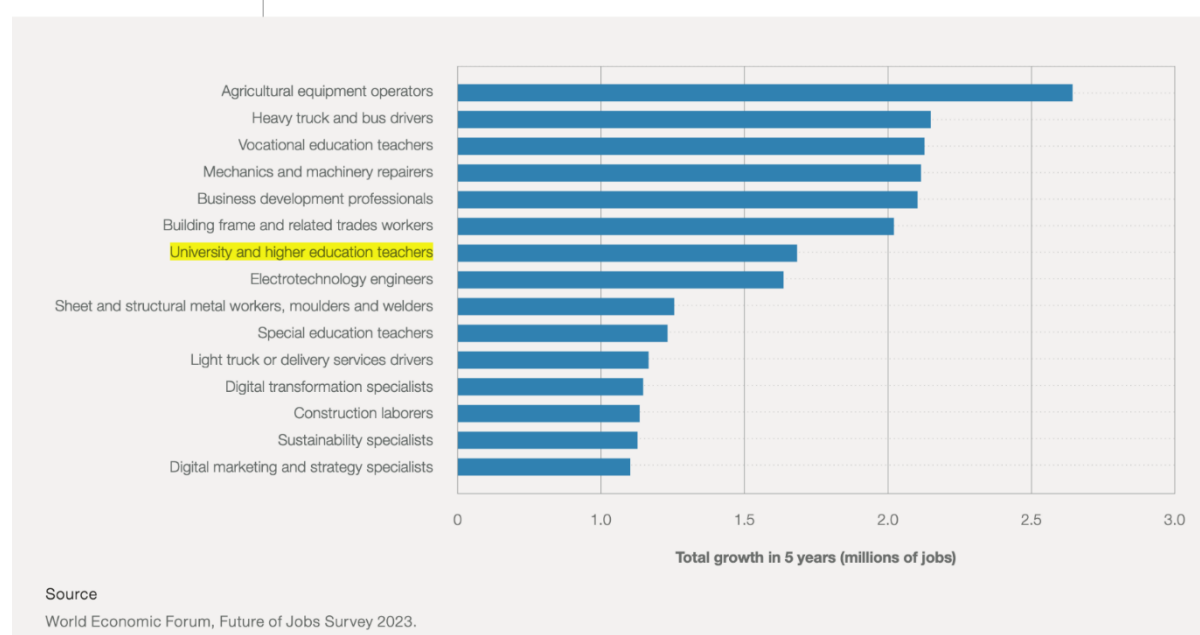
## **2. The Impact of the Fourth Industrial Revolution on the Labor Market**

The scale of these changes is most visible in the transformation of the labor market. At the beginning of the industrial revolution, alarming predictions were made. For instance, in 2018, it was forecasted that by 2022, machines would take over 42% of jobs and by 2027, 52%, relegating humans to the

background in the labor market (Future of Jobs, 2018). However, actual data are somewhat lower: by 2022, 34% of jobs had been automated, and a projection of 43% automation by 2027 was made based on 2023 measurements (Future of Jobs Report, 2023). Facts show that by 2023, 23% of jobs had disappeared, replaced by new occupations, and in the long term, it is anticipated that 69 million new jobs will be created in the next five years due to new technologies and the green transition. However, the other side of this process is that 83 million jobs will be at risk due to these changes. Thus, summing up the number of existing jobs, it becomes evident that a quarter of jobs will disappear in the next five years, resulting in significant transformations in the labor market (Forum Institutional, 2023). It is worth examining the fastest-growing professions globally, where the largest increases in job creation are expected. Technology operators rank first, while vocational trainers, who prepare people for these professions, are in third place.

A clear consequence of the changing workforce demands caused by the Fourth Industrial Revolution is that retraining will play a significant role in the future. Globally, it is expected that 44% of workers will need new skills (Forum Institutional, 2023), posing a substantial challenge for educational science.

FIGURE 3.4 **Largest job growth, millions**  
Top roles ordered by largest net job growth, calculated based on ILO Occupation Employment statistics and growth reported by organizations surveyed



*Largest job growth in the next 5 year (Future of Jobs Report 2023)*

### 3. Artificial Intelligence and Big Data Competencies

Retraining will focus on competencies demanded by the labor market, and forecasts indicate that globally, 32% of workers will require retraining in AI and big data capabilities. In Serbia, it is expected that 33% of the workforce will need to develop these skills (Forum Institutional, 2023). The role of artificial intelligence and big data in the future has been examined in other studies. In December 2023, Amazon conducted a survey in the United States involving over 1,300 companies and 3,000 employees, and over 90% of the employers surveyed predicted that they would adopt AI-related solutions in their organizations by 2028. In March 2024, a similar study was conducted in Europe with more than 2,000 companies and 6,000 people. The results were similar: 91% of employers and 86% of employees expect generative AI to be used in the next five years to boost innovation and creativity, automate repetitive tasks, and enhance learning (AWS, 2024).

#### **4. Big Data and Artificial Intelligence**

Big data and artificial intelligence competencies involve executing workflows where data analysis and intelligent systems are closely tied to decision-making processes. This encompasses collecting, storing, and analyzing large volumes of data and applying AI tools, such as machine learning algorithms and predictive models, to solve problems.

The significance of big data and AI technologies surged during the Fourth Industrial Revolution, as these tools enable data-driven decision-making, which is crucial for maintaining competitiveness. AI, for instance, can identify patterns in data that remain hidden to human analysts and help forecast future trends. Meanwhile, big data technologies address challenges related to data processing and storage, enabling rapid access to and real-time analysis of data.

The application of AI and big data technologies is not limited to the corporate sector; their continuous expansion is also evident in government, healthcare, and education. According to the World Economic Forum (2024), AI- and big data-based systems can improve operational efficiency by up to 15% by optimizing business processes, reducing costs, and creating new revenue streams.

In the next chapter, we will examine the impact of artificial intelligence on the educational system!

#### **5. The Impact of Artificial Intelligence on the Educational System**

The emergence of artificial intelligence has fundamentally transformed numerous areas of social life, and education cannot remain an exception in the long run. There are already countries where AI applications have become an integral part of educational institutions, revolutionizing the ways students learn, teachers teach, and institutions operate (Aldosari, 2020; Antal, Czeglédi, 2022; Narendra et al., 2023; Guan et al., 2020; Kamalov et al., 2023, Kocka, Prantner & Bíró, 2023).

The integration of artificial intelligence into various EdTech solutions gradually transforms the learning environment. One of the most significant outcomes of this transformation is evident in the personalization of learning pathways. This is achieved by analyzing data collected during students' learning processes, identifying individual learning characteristics, and tailoring educational experiences accordingly.

Additionally, the widespread use of AI in education is expected to improve learning outcomes, increase student engagement, and reduce dropout rates. AI-based tools can provide instant feedback on practice tasks, while also enabling more accurate assessment of students' knowledge and performance. Advanced EdTech systems can support teachers in numerous other areas. One notable opportunity lies in the automation of certain administrative tasks, such as the creation of practice problem sets, allowing educators to focus more on instructional activities and student support.

However, the use of AI in education is not without challenges. Concerns have been raised regarding data privacy, learned biases, and the potential depersonalization of the learning experience. Worryingly, these intelligent tools may present content that is pedagogically inappropriate or undermine essential skills like writing, reading, and reasoning (Felix & Webb, 2024; Ayala-Pazmiño, 2023).

Despite these challenges, the promise of artificial intelligence to enhance the quality and accessibility of education remains compelling. As AI technologies continue to evolve, rigorous research and careful implementation will be critical to ensure the full realization of their educational benefits while mitigating potential risks.

#### **6. Intelligent Tutoring Systems**

AI-powered EdTech tools, particularly intelligent tutoring systems (ITSs), have gained prominence. These systems use advanced machine learning algorithms and models to assess students' unique knowledge, skills, and learning preferences, and adaptively determine optimal educational goals and tailor content accordingly (VanLehn, 2011). Combining computer vision and natural language processing techniques, ITSs can automate the grading, evaluation, and sometimes the scoring of assignments, tests, and exams (Chaudhri et al., 2013). This higher level of automation not only reduces the workload for teachers but also provides students with relevant, real-time feedback, enhancing their learning engagement (Graesser et al., 2005).

By continuously monitoring students' progress, identifying knowledge gaps, and intervening to modify the learning process, ITSs enable a level of personalization that is challenging to achieve in traditional classroom settings. This elevated level of personalized support has been shown to significantly improve the retention of knowledge and skills acquired during the educational process (VanLehn, 2011).

## **7. The Main Components of ITS Architecture**

As we have seen, ITSs are sophisticated AI-based educational platforms typically comprising four interconnected components: the domain model, the student model, the pedagogical model, and the user interface.

### **Domain Model**

The domain model encompasses the comprehensive subject knowledge and content from which the ITS draws during the teaching process. This foundational knowledge base forms the backbone of the educational materials and learning activities optimized for students.

### **Student Model**

The student model tracks and models the learner's evolving understanding, progress, and learning behavior. By continuously updating the student profile, the ITS dynamically adjusts the teaching process, supportive functions, and feedback to align with the strengths, weaknesses, and learning styles of individual learners.

### **Pedagogical Model**

Based on the analysis of the student's individual needs, preferences, and performance, the pedagogical model determines the most effective teaching strategies, instructional methods, and learning activities to apply. This adaptive, data-driven pedagogical approach aims to ensure an optimized learning experience for each student.

### **User Interface**

The user interface is the interactive platform through which communication occurs between the learners and the tutoring system. A well-designed interface is intuitive, easy to use, and visually supportive, helping students process and absorb information effectively. Modern ITS user interfaces often include gamification elements, visualizations, and adaptive features that further align the system with diverse learning styles and preferences. Additionally, interfaces may utilize technologies such as natural language processing or voice-based commands to enhance the learning experience.

## **8. Concerns About the Functioning of ITSs**

Although ITSs offer significant potential benefits in enhancing personalized and adaptive learning, some researchers have raised valid concerns regarding the risks and ethical considerations associated with their implementation. For example, the collection and use of data by ITSs on students' cognitive abilities or other personality traits raise critical data protection and security issues, making proper management of these concerns a fundamental requirement for their operation (Akgun & Greenhow, 2022). Furthermore, biases inherent in the development or training of certain AI technologies may lead to deviations from the true educational goals, potentially undermining the holistic development of students (Baker & Hawn, 2021).

It is therefore essential to monitor, validate, and oversee deployed systems. This requires continuous collaboration between educators using the technology and researchers developing it to create robust ethical frameworks and safeguards that ensure the responsible and equitable application of these transformative technologies (Zawacki-Richter et al., 2019).

## **9. The LLM Architecture for Educational Tasks**

The advent of large language models (LLMs) in education can revolutionize diverse tasks, such as curriculum design or lesson planning. These models can also assume roles such as lecturers, mentors, or collaborative partners, offering additional pedagogical benefits while presenting accompanying risks (Mollick & Mollick, 2023). For instance, concerns may arise regarding students' potential dependence on generative AI, which could result in a lack of critical thinking or complacency. The issues of inherent

biases in LLMs and occasional inaccuracies, known as "hallucinations," also pose challenges that could adversely affect the educational process.

Effectively addressing these risks requires a multifaceted approach. Firstly, educators must be prepared to actively oversee the learning process, providing guidance, context, and alternative perspectives to encourage the critical use of LLM-powered tools. Secondly, students must be trained to critically evaluate the information and recommendations provided by such systems. By enhancing digital literacy and critical thinking skills, learners can recognize the limitations and biases of generative language models and develop the ability to complement AI-generated insights with their unique perspectives and problem-solving approaches.

## **10. Potential Integration of LLMs into ITSs**

The future convergence of LLMs and intelligent tutoring systems (ITSs) presents the possibility of another paradigm shift in education. By combining the personalized, adaptive, and interactive capabilities of ITSs with the powerful natural language processing and generation capacities of LLMs, educators can create transformative learning experiences.

An ITS-guided and controlled large language model could provide highly personalized, tailored learning experiences to meet the unique needs and preferences of individual students. The LLM component could generate real-time, customized feedback, explanations, and learning content, while the ITS's pedagogical model ensures that each educational activity aligns with the student's learning style and progress (Leiker et al., 2023; Gan et al., 2023).

Moreover, integrating LLMs could enhance ITS assessment capabilities, enabling more accurate and comprehensive tracking of students' performance and understanding.

LLMs' use in educational contexts can also foster students' creativity and critical thinking. Instead of merely replicating or recounting received information, students could use LLM-based tools to generate ideas, explore different perspectives, and develop their problem-solving skills.

By leveraging the strengths of ITSs and LLMs, we can usher in a new era of personalized, adaptive, and engaging learning experiences, equipping students to navigate the challenges of the 21st century successfully.

## **11. The Impact of LLMs on the Gradual Transformation of Education**

The impact of large language models integrated into educational settings extends far beyond the classroom, offering profound opportunities to rethink and transform educational practices. Their potential effects range from curriculum design and holistic evaluation of student progress across subjects to equitable access to educational resources and the renewal of teacher training.

By incorporating LLM-driven ITS tools for content generation and curation, educators can design dynamic, interactive, and multimedia-rich educational experiences that more effectively engage students and deepen understanding.

In teacher training and professional development, LLMs can also serve as invaluable tools, assisting with lesson planning, providing real-time feedback on teaching effectiveness, and offering personalized guidance. This enables teachers to enhance their skills and adapt to the evolving needs of their students. These future integrated tools could bolster pedagogical goals while fostering a culture of continuous professional growth.

LLMs can also help bridge gaps in access to quality educational resources, particularly in underserved and resource-constrained communities. By automating the creation and curation of educational materials, these tools could provide broader access to engaging and effective content tailored to diverse learning needs, even in situations of limited teaching resources. Democratizing access to ITS technologies could reduce inequities in education.

## **12. Holistic Assessment**

The application of LLMs can transform the way learning achievements are measured and progress is tracked. Exploiting advanced natural language processing capabilities, educators can design comprehensive and nuanced assessment tools that go beyond traditional formats. These tools could evaluate not only what students know but also how they think, express themselves, and apply their knowledge in various contexts. This transformative approach offers significant pedagogical advantages, enabling educators to better understand and support student learning.

LLMs can assess not only the correctness of answers but also the depth and coherence of a student's reasoning. By analyzing language use, structure, and clarity, they can provide insights into a student's ability to interpret, utilize, or articulate complex concepts in their own words (Gan et al., 2023). These tools also allow for evaluating the transfer of learning across disciplines, measuring how well students apply acquired knowledge to novel problems (Mollick & Mollick, 2023).

Traditional assessments often compartmentalize student performance by subject, making it challenging to gain a comprehensive view of overall progress. LLMs can bridge this gap by assessing student performance across disciplinary boundaries. For example, they can evaluate how students simultaneously use literacy and numeracy skills in interdisciplinary tasks, such as writing a research report or solving real-world problems. This technology can also be used for cross-context understanding assessments, evaluating how students recognize and apply connections between subjects—for example, employing mathematical reasoning in a scientific experiment or providing historical context in a literary analysis (Leiker et al., 2023).

### **13. Pedagogical Benefits of Holistic Assessment**

Integrating LLM-supported holistic assessment into ITSs offers several pedagogical benefits that can significantly enhance teaching and learning outcomes:

#### **Information-Based Learning Organization:**

Holistic results allow educators to tailor instructional strategies based on a detailed understanding of individual students' strengths and areas for improvement. For instance, identifying difficulties in mastering scientific concepts can prompt the use of personalized, analogy-based examples during science lessons.

#### **Higher-Level Differentiation:**

Deeper insights into individual learning profiles enable subject teachers to provide personal, targeted, and unique support during acquisition. This differentiation is particularly beneficial in diverse classrooms where students have varying learning needs and preferences (Mollick & Mollick, 2023).

#### **In-Depth Assessment and Feedback:**

The holistic approach provides detailed, data-driven assessments that go beyond scores and grades. Students can receive guidance to improve critical thinking, reasoning, and creativity, fostering intellectual and personal development (Gan et al., 2023).

#### **Fostering Interdisciplinary Learning:**

By evaluating how students integrate knowledge across subjects, LLM-supported assessments encourage interdisciplinary thinking. This prepares students for real-world challenges that require complex, multifaceted problem-solving skills.

#### **Equitable Assessment and Effective Mentoring:**

Automated assessments reduce the burden of manual grading while ensuring high precision and depth. This efficiency frees teachers to focus on educational tasks and mentoring students.

### **14. Conclusion**

Our research has highlighted that the widespread adoption of artificial intelligence in education can bring about significant transformations that extend far beyond traditional teaching and learning processes. In light of the technological and societal changes driven by the Fourth Industrial Revolution, education must adapt to the new competency demands of the labor market while leveraging the potential of AI-based solutions. Our findings clearly demonstrate that the integration of intelligent tutoring systems (ITSs) and large language models (LLMs) can open new dimensions in educational practice, particularly with regard to personalized learning pathways, engaging learning processes, and opportunities for holistic assessment.

The advanced algorithms of ITSs integrated with LLMs can be tailored to adapt in real time to the needs and abilities of students, ensuring the comprehensive customization of educational content and methods. Thanks to advancements in natural language processing technologies, LLMs now offer new possibilities in content generation, support for interdisciplinary learning, and the implementation of

holistic assessment approaches. Such assessments not only facilitate the quantitative measurement of students' knowledge but also enable educators to uncover students' reasoning skills, creative thinking, and capacity for interdisciplinary knowledge integration. These developments promote an educational approach that goes beyond developing subject-specific skills to fostering learners' complex problem-solving abilities.

However, the application of AI-based technologies for educational purposes is not without its challenges. Our research has underscored issues related to the protection of personal data, algorithmic biases, and the potential dehumanization of the educational process. These concerns underscore the necessity of establishing rigorous regulatory frameworks to ensure the responsible and equitable application of AI tools. Additionally, we must emphasize the importance of preparing educators to critically and reflectively apply AI technologies, thereby supporting the development of students' digital literacy and critical thinking skills.

## 15. Outlook for the Future

The findings of our research clearly outline the most promising developmental directions for the educational use of artificial intelligence. The integration of large language model (LLM) technologies with intelligent tutoring systems (ITSs) encompasses advanced natural language processing capabilities, such as the realization of holistic assessment, which represents a significant pedagogical innovation in its own right. At the same time, this approach not only enables the multidimensional evaluation of students' current knowledge but also provides deeper insights into their developmental trajectories and learning strategies. Integrating interdisciplinary learning objectives and assessing skills and knowledge transfer across specific subjects has the potential to fundamentally reshape the goals and methods of education.

However, the future convergence of ITSs and LLMs will not only enhance educational efficiency but also contribute to more equitable access to educational resources, particularly in resource-scarce communities. We have found that upon reaching a certain level of maturity, these ITS-integrated generative AI tools could democratize future education. They could achieve this by ensuring that the educational materials and automated assessment tools they generate—designed to accommodate the diverse needs and abilities of learners—become accessible to all.

Our research concludes that the responsible development and application of AI technologies can make educational systems more effective, engaging, sustainable, and equitable. Future research must focus on the further development of holistic assessment tools, strengthening the AI competencies of teachers and students, and creating and implementing ethical guidelines. Collectively, these processes could contribute to establishing an educational system that not only supports teachers' professional growth and the full realization of students' individual potential but also adequately prepares learners to meet the global challenges of the 21st century.

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