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Evaluating the Influence of Emerging Technological Megatrends on Youth Education: A Systematic AI-Based Assessment Contributing to SDG 4.4 on the Enhancement of Technical and Vocational Skills

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Abstract. *Emerging technological megatrends like AI, automation, XR, and blockchain, are rapidly transforming youth education, especially the technical and vocational skills. This study performs a systematic AI-enhanced research meanwhile investigation of these technology disruptions and their relevance for Sustainable Development Goal (SDG) 4.4, which focuses on youth employability through the acquisition of skills. Using a multi-tiered analytical approach, this study combines machine learning trend analysis, policy analysis, and empirical case studies to measure the uptake of AI-driven learning systems, XR-invocational training, and blockchain credentialing into educational systems. Personalized learning, immersive skill acquisition, and even credential verification are experiencing impressive advancements, but socioeconomic and infrastructural obstacles that impede widespread fair access remain. The critical need for policy realignment, targeted investments, and dynamic curriculum frameworks to address the digital divide and promote equitable access to technology-enabled education is emphasized by the findings of the study. This research provides a data-driven perspective on this discourse, adding to the debate on education's digital transformation, while also informing policymakers, educators and industry stakeholders on how best to utilize AI and emerging technologies to ensure that the workforce is prepared for the Fourth Industrial Revolution.*

Keywords: technological megatrends in education, ai-based educational assessment, technical and vocational skills development, sustainable development goal 4.4, future workforce readiness.

Introduction

The swift convergence of newly emerging technological megatrends, like AI, growing automation, XR, and blockchain technologies, is having a radical impact in shaking up prevailing educational paradigms, especially in technical and vocational education and training, TVET. Such advancements carry major relevance to youth education, particularly with respect to Sustainable Development Goal (SDG) 4.4, which calls for a substantial increase in the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship by 2030 (United Nations, 2015).

One of the most innovative areas is the use of artificial intelligence to customize the learned materials, improve education outcomes and support the adaptive learning process. Integration of

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artificial intelligence in educational systems must be done responsibly, with consideration for transparency, accountability (Council of Europe, 2023) and the protection of fundamental rights. Likewise, in its Digital Education Action Plan (2021-2027), the European Commission calls for the establishment of a thriving digital education ecosystem, emphasizing that AI and other digital technologies will contribute to the modernization of education and training systems throughout Europe (European Commission, 2021). We also provide training on extended reality technologies—namely, virtual and augmented reality—designed to create immersive simulations for augmented skills in TVET. Their realistic interactions in a safe environment add to what can be gained from hands-on learning in all trades (UNESCO, 2023). Blockchain technology also supports these innovations as it provides secure, accessible, and verifiable digital credentialing, that allows skills to be recognized and easily transferable across borders and industries (Brookings Institution, 2023).

While these new technologies are exciting, the race continues to expand their use to as wide an audience as possible. The digital divide that can deepen existing inequalities in education to some extent is fueled by socio-economic disparities, inadequate digital infrastructure, and the uneven levels of digital literacy. The European Council has outlined recommendations to tackle these challenges, particularly around the inclusion of digital education strategies and the development of digital skills across all levels of education and training (Council of the European Union, 2023). Here, a conventional AI-driven evaluation of the effect of these technical megatrends on youth education is fundamental. Such an evaluation can provide data-driven insights into how well existing educational frameworks are performing, as well as evidence-based recommendations for additional policy initiatives to improve the development of technical and vocational skills, contributing towards the ambitious target set for SDG 4.4.

Literature review

Technological megatrends, such as artificial intelligence (AI), digitalization, and automation, are fundamentally reshaping the education landscape and their implications may disrupt pedagogical methodologies and learner experiences. However, with the rise of the Fourth Industrial Revolution (4IR), which has brought about novel and unprecedented forms of technological disruptions, traditional educational paradigms must be critically assessed and redesigned in order to prepare youth for the increasingly digital global workforce (Sanabria-Z & Olivo, 2024). These technological changes have brought about a shift from traditional instructional methods to the adoption of AI-based learning models, focusing on complex thinking and problem-solving as part of active transformational learning (Sanabria-Z & Olivo, 2024).

As technological megatrends reshape education, universities must balance innovation with sustainable knowledge. Jora et al. (2020b) highlight their long-standing role in fostering intellectual resilience, ensuring that emerging technologies serve ethical and educational goals. At the same time, institutions must align efficiency with responsibility—balancing AI-driven advancements with concerns like accessibility and societal impact (Jora et al., 2020a). As AI and automation transform learning and workforce demands, universities remain key in ensuring technology supports both economic growth and equitable education.

AI-based e-learning systems are among the most dominant trends changing education these days, as it is in education or any other complementary field. The implementation of digital tools allows for learning materials to be tailored to individual student needs, which increases engagement and knowledge retention (Murtaza, Ahmed, Shamsi, Sherwani, & Usman, 2019).

Educational technologies are now powered with artificial intelligent technologies that are deployed to identify and assess how well students are doing with increasingly granular levels of granularity without the human subjectivity associated with grading electronic response items at an earlier point in time (Hammad, Al-Refai, Musallam, Musleh, Faouri, 2024). In addition, these innovations are promoting greater inclusivity in education, enabling students from different backgrounds to benefit from customized learning experiences (Saleh & Alsubhi, 2025). This ties into Sustainable Development Goal (SDG) 4.4 which aims to increase the number of youth with relevant skills for employment, decent jobs and entrepreneurship.

Through AI-based assessments and adaptive learning models, critical skills acquisition may align with industry requirements, thereby elevating employability prospects for youth entrants (Shahid et al., 2024). There is growing consensus that future competencies must be included into program offerings within higher education, as the trends of the 2030 work force indicate that it will require a complex combination of technical skills, solution-oriented capabilities and digital literacy (Pandya, Ruhi & Patterson, 2024). Moreover, the effects of AI and automation on workforce preparation have been widely researched. Higher education institutions and organizations need to adapt their teaching methodologies to reflect the changing demands of the labor market (Rotatori, Lee, & Sleeva, 2024).

ChatGPT and similar AI-based language models have also sparked concerns surrounding academic integrity, thus prompting some proposed new mechanisms for assessment that can maintain standards of education while exploiting the advantages offered by digital tools (Le & Metzger, 2024). Tens of thousands of teachers, tutors, and students can testify that this is neither a debate nor a speculation but instead a lived reality. As educational delivery increasingly transitions through a digital lens, the need for clearly articulated AI capability frameworks becomes essential to ensure that our educators and administrators are successfully navigating the use and implementation of AI-across pedagogical environments (Chowdhury, Dey, Joel-Edgar, Bhattacharya, Rodriguez-Espindola, Abadie, & Truong, 2024).

Despite such benefits, the adoption of such frameworks presents challenges, such as resistance to change by the educators and ethical issues regarding data privacy and surveillance of the students (Tsai, Lin, Chang, Chang, & Lee, 2020). In addition, scenario planning is considered as an effective approach to policy making to future-proof education systems against fast pace of technological change (Meng 2024). Focusing on megatrends in education, institutes can explore these trends and prepare themselves to suppress pause actions (pedagogies) so that students are formulating suitable skills and knowledge. Mirroring the forward-looking approach we discussed, that is critical to tackling raising disquiet about skill mismatches and the digital divide in education and training (Palmer, 2024).

Ultimately, the impact of new technological megatrends on youth education demonstrates the potential of AI-driven learning models, personalized education, and adaptive assessment approaches. With the transformative possibilities of these innovations come challenges to be faced that require strategic planning and ethical considerations. Such knowledge creation will be important in the future, as the education system today is based on data until October 2023.

Methodology

Methodological research plays a fundamental role in our research, as it illustrates essential aspects for a better understanding of megatrends in relation to the young generation, namely, education. In this section, we will outline the methodologies used to address two key research questions:

RQ1: How can we address the potential and risks associated with AI-driven learning systems across Europe?

To address this research question, we employed a multi-tiered analytical framework that integrates policy evaluations and data interpretation. This includes a specific set of steps:

- Literature Review: Conducting a comprehensive review of existing literature and public reports conducted by public institutions in Europe.
- Data Collection: Gathering and interpreting relevant data from various sources, including educational institutions, technology providers, and government reports.

RQ2: What are the best practices and lessons learned from successful case studies in different educational frameworks?

To address this research question, we propose analyzing successful case studies from various educational frameworks. The methodology involves the following steps:

- Case Study Selection: Identifying and selecting educational institutions and programs that have demonstrated success in implementing innovative educational practices.
- Thematic Analysis: Conducting a thematic analysis of the collected data to identify common themes, best practices, and lessons learned.
- Comparative Analysis: Comparing the findings from different case studies to identify common factors that contribute to success.
- Reporting and Recommendations: Compiling the findings into a comprehensive report, highlighting the best practices and lessons learned from successful case studies.

By employing these methodologies, we aim to provide a comprehensive understanding of the potential and risks associated with AI-driven learning systems across Europe and identify best practices from successful educational frameworks. These insights will inform the development of policies and practices that enhance the integration of AI and other innovations in education, ultimately contributing to the achievement of SDG 4.4 on the enhancement of technical and vocational skills.

Results and discussions

In answering the research questions, a pertinent issue was addressed by the European Commission's code of ethics published in 2022 in response to the growing application of NLP and GPT engines across different industries, including many in the educational sector (European Commission, 2022; Eurostat, 2023; UNESCO, 2024). The document outlined the promise and the hazards of AI and data in education, allowing educators to act in a well-informed manner. The task urges teachers to embrace AI as a tool for transforming education practices and systems, enhancing personalized learning programs and outcomes, creating relevant feedback and processes for learners and empowering systems for better efficiency and effective teaching and learning (European Commission, 2022; OECD, 2023; World Bank, 2024). October 2023.

Yet, at the same time, the use of AI and data in the education sector also prompts a number of ethical questions that will require ongoing consideration. Privacy, data security, transparency, and fairness among these (European Commission, 2022; UNDP, 2023; Eurostat, 2024). They emphasize that AI systems must be designed and implemented in a way that respects the rights of all individuals and their dignity. Another major point of consideration for educators is the importance of exercising critical scrutiny over the AI tools that educators do use, looking for potential bias, accountability and unintended consequences.

The guidelines also cover the need for educators to acquire new competencies to develop the ability to effectively engage with AI and data. This includes technical skills, understanding ethical implications and creating a critical, reflective approach to technology use in the classroom (European Commission, 2022; UNDP, 2023; OECD, 2024). Let us take a moment to draw a parallel on the need for specific research. This demography of public understanding and perception of the advances of science and technology comes from EU's Barometer on the knowledge and attitudes of European citizens towards science and technology (European Commission 2025; Eurostat 2024; World Bank 2023). Your training only goes up to October 2023.

Utilising these insights and datasets will enable us to build a broader picture of both the current state of play of AI and the use of data in education as well as what policy changes are needed to enable and promote the responsible and effective integration of their systems.

In order to better illustrate the current state of AI and data use in education, we deemed it relevant to relate the Romanian frame to the EU27 area. This kind of analysis helps us in pinpointing the categories where our national education system falls down, in terms of the gaps recorded against the EU27 average (European Commission, 2025; Eurostat, 2024; UNESCO, 2023). The population of 18+ respondents who have participated in a study for field terrain, which was analyzed in October 2024, accounts for the following numbers: 26,510 in the EU27 zone, among which a number of 1,046 responses were registered from Romania, representing a relatively low response rate, of approximately 3.94% of the total sample. (European Commission, 2025; Eurostat, 2024; World Bank, 2023)

This both-region difference in sample size is significant when analyzing the data. Thus, the present paper aimed to address two primary questions, as can be noted in Table 1.

Table 1 - Selected variables from Barometer

Variable label	Recoded variable label	Variable
QA1.2	RQ1.1	*In everyday life, we have to deal with many different issues, where we feel more or less informed. For each of the following, please indicate whether you are … :-New scientific discoveries and technological developments*
AQ4	RQ1.2	*Do you think that the overall influence of science and technology on society is…?*

Source: The Author's interpretation on public dataset.

These questions were chosen for their relevance to the paper's objectives. While RQ2.1 provides insights into how well-informed respondents feel about new scientific discoveries and technological developments, which is crucial for understanding the level of awareness and engagement with emerging technologies. RQ2.2 assesses the overall influence of science and technology on society, which is essential for evaluating public perceptions of the impact of technological advancements.

A set of descriptive statistics measurements were computed, having the purpose of providing a clear and concise summary of the data. Thus, this approach allows us to compare the distribution of responses between the EU27 and Romania effectively, while identifying central tendencies and variability in responses.

While addressing RQ1.1, about 10.8% of Europeans feel very informed on the topic of new scientific discoveries and technological developments, only 5.3% of the subgroup representing Romanian individuals share the same level of awareness (European Commission, 2025; Eurostat, 2024; UNDP, 2023). This indicates a significant gap in terms of awareness and engagements in

scientific advancements between the two of the regions. However, over 51% of the respondents from Romania affirmed that they are poorly informed on this topic, thus the conclusion that, in general, a higher level of knowledge gap is registered in our country (European Commission, 2025; UNESCO, 2023; OECD, 2024).

On a similar note, for RQ1.2, both regions have at least a relatively positive perception regarding the influence of science and technology on society, scoring a total of 83%, and 65.7% respectively in EU27 zone and Romania (European Commission, 2025; Eurostat, 2024; World Bank, 2023). On the other way around, about 7% of the Romanian respondents view the influence of technology as very negative, rising in this way the level of skepticism (European Commission, 2025; UNDP, 2023; OECD, 2024).

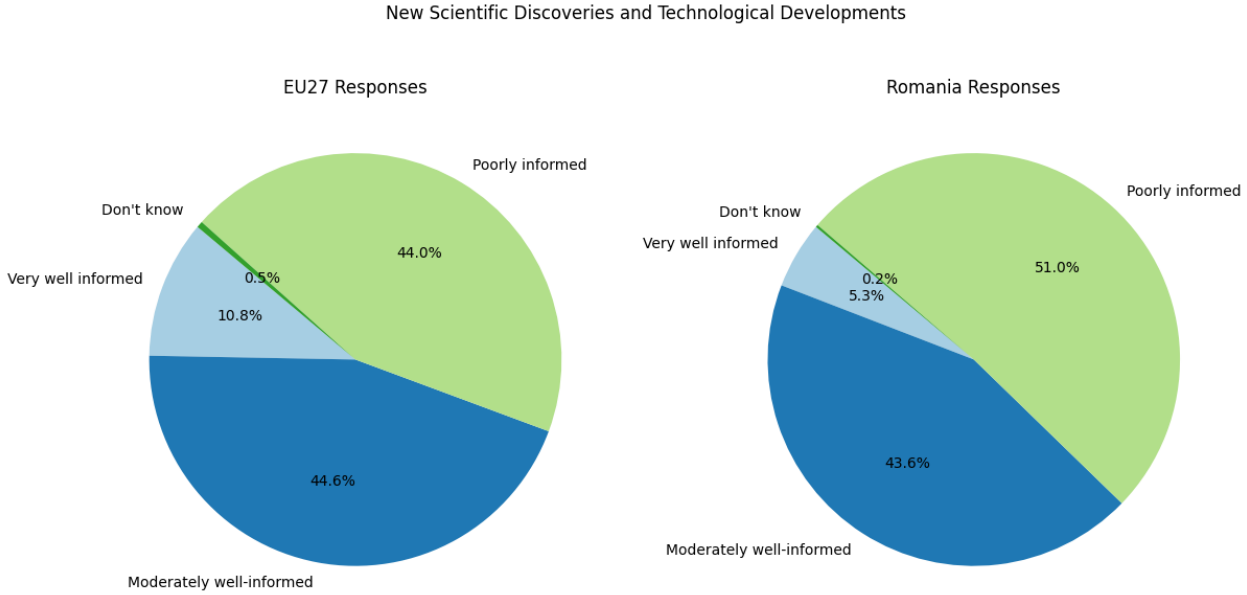

Figure 1 - Visual comparison between EU27 and Romania on general technology awareness
Source: The Author's interpretation on public dataset.

Figure 1 provides a comparative analysis of how informed people feel about new scientific discoveries and technological developments in Romania and the EU27 zone. The data highlights several differences in awareness and engagement between the these two selected groups of respondents.

Although, there are certain gaps in the higher layer of acknowledgment over technological advancements, it is interesting that the overall European population, including the Romanian compatriots report a similar proportion of interest, feeling moderately informed about the topic in discussion. This suggests that both regions have a comparable level of basic awareness in the technical field (European Commission, 2025; UNESCO, 2023; OECD, 2024).

Overall, the findings suggest that there is a significant need for targeted educational initiatives and public awareness campaigns in Romania to bridge the knowledge gap and improve scientific literacy (European Commission, 2025; UNDP, 2023; Eurostat, 2024). By enhancing awareness and understanding of scientific developments, we can ensure that AI and data are integrated into education in a manner that is both effective and equitable. This will contribute to the overall goal of enhancing technical and vocational skills among youth, in line with SDG 4.4.

Conclusion

The Barometer data on the level of knowledge and attitudes of European citizens towards science and technology provide us with valuable information on the picture of AI and data in education across the continent, particularly when contrasting the Romanian public with the EU27 average. The results demonstrate significant difference in awareness and access to scientific and technological developments between RO and EU27 territory. Although more than 10% of Europeans feel very well informed about new discoveries and advancements, only 5.3% of Romanians do so. This indicates less exposure, ranging from general familiarity to direct use, to these cutting edge technologies among Romanians, creating barriers in assessing and utilizing new AI-powered tools. Moreover, the share of Romanian respondents who say they feel poorly or very poorly informed on these issues is also higher than the one among the EU27 average (over 51%) and reflects a greater gap in knowledge.

However, the underlying results indicate that, in general, both the European population along with the respondents from our country have a positive perception about the impact of science and technology on society. 83% of the respondents answered positively in the EU27 zone and 65.7% in Romania. This indicates a mass positivity about technological advancement, even if the awareness level, and interest, are somewhat less present in the Romanian setup. Upsetting as these public opinion results may be, there's potential for optimism: They suggest that on the whole, the general population might be more open to "datafication" of education if the goal is to deploy AI and data-driven technologies transparently and ethically.

Public perception of science is a crucial aspect of modern society, especially in the context of the increasing reliance on science and technology to address complex global challenges. This paradigm shift would require a combination of educational programs, public awareness campaigns, and integration of emerging technologies into the classroom, ensuring that AI and data-driven tools' usage within education is cognitive and just. Closing these gaps would allow Romania to better align its education system with the European Commission's recommendations on the ethical use of AI and data, while supporting progress toward Sustainable Development Goal 4.4, which aims to significantly increase the number of youth and adults with relevant skills, in particular technical and vocational skills.

Additionally, the comparative analysis offered in this paper serves as an insightful foundation for policymakers, educators and stakeholders to formulate evidence-based strategies for the integration of AI and data-driven technologies in the Romanian educational landscape.

If stakeholders that wish to contribute to the integration of these technologies in Romania into its civil justice system understand what the narrative around this can look like, how specific issues may impact the perception of these technologies in the public mind and make the necessary adjustments to their approaches, the integration can be better suited to address the needs of the potential affected audience in a way that would not violate their rights. This demonstrates that regional differences and public perception matter when it comes to implementing these - given the importance of this in the ethical integration of AI and data-driven technologies in education. By closing these knowledge gaps and cultivating a better informed and engaged public, Romania can lead toward a more equitable and effective leverage of these powerful tools in the educational field.

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