



Artificial Intelligence in the European approach to Education: Perspectives, perceptions, and mistrust

Intelligenza Artificiale nell'approccio europeo all'educazione: Prospettive, percezioni e diffidenze

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ABSTRACT

This contribution examines the ongoing debate concerning the role of artificial intelligence in education (AIEd), and focuses on the challenges and opportunities posed by the new technologies in the EU. The future perspectives of AIEd in the EU encompass a broad spectrum of ethical, regulatory, educational, and societal considerations, reflecting a proactive and multifaceted approach to addressing the new emerging context. The paper also visualizes the intellectual map of the European academia engaged in AI-related research through bibliometrics, revealing the main topics and gaps in the current debate. The scrutiny reveals a lack of documented practical case studies to support education professionals, while the current debate focuses mostly on ethical and regulatory issues.

Questo contributo esamina il dibattito in corso riguardante il ruolo dell'Intelligenza Artificiale nell'Educazione (AIEd) e si concentra sulle sfide e le opportunità poste dalle nuove tecnologie nell'UE. Le prospettive future dell'AIEd nell'UE comprendono un ampio spettro di considerazioni etiche, normative, educative e sociali, riflettendo un approccio proattivo e poliedrico al nuovo contesto emergente. Il documento visualizza anche la mappa intellettuale dell'accademia europea impegnata nella ricerca legata all'IA attraverso la bibliometria, rivelando i principali argomenti e le lacune nel dibattito attuale. L'analisi rivela una mancanza di studi di caso pratici documentati a supporto dei professionisti dell'educazione, mentre l'attuale dibattito si concentra principalmente su questioni etiche e normative.

KEYWORDS

Artificial Intelligence in Education, Artificial Intelligence in the European Union, AI in Educational Settings, EU's Strategies for AI, Keyword mapping
Intelligenza Artificiale nell'Educazione, Intelligenza Artificiale nell'Unione Europea, IA in contesti educativi, Strategie dell'UE per l'IA, Mappatura delle parole chiave

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1. Introduction

The Coordinated Plan on Artificial Intelligence (AI), issued by the European Commission (EC, 2021) included as its main goal promoting the application of a European approach to AI and creating global leadership in human-centered AI. The plan proposes a series of joint actions for all member states on how to develop this leadership, including accelerating investments in AI technologies, implementing strategies and programs in a timely and full manner, aligning AI policies to address global challenges and removing fragmentation. The document also suggests that it is necessary to gradually increase public and private investments in AI until reaching a total of 20 billion euros per year over the next decade. Furthermore, the EU is actively addressing the risks associated with AI in education (AIEd) through its proposals of regulatory measures, emphasizing the need for ethical and legal frameworks, and promoting transparency and governance. The main purpose of these guidelines (EC, 2022) regards the use of AIEd by the application of ethical frameworks for the safe and responsible use of data in teaching and learning. These guidelines aim to ensure that teachers understand the potential that AI and big data can have in education, while being aware of the associated risks. As a further matter, they intend to provide practical examples of how AI is currently being used to support teaching and learning. These efforts are consistent with the EU's broad vision of using AI for the benefit of society and protecting fundamental rights, and member states aim to ensure that the use of AI benefits individuals and contributes to more inclusive societies (Zalite & Zvirbule, 2020). The EU AI Act proposes measures to ban AI systems that manipulate individuals through subliminal techniques or exploit the vulnerability of certain groups, thus potentially causing harm (Franklin et al., 2022). Additionally, the EU has emphasized the need for robust ethical and legal frameworks to safeguard fundamental rights while promoting public and private investments in AI technology and preparing for socio-economic changes (Katuli, 2021). The EU's approach aligns with the vision of preparing society for the widespread use of this paradigm-shifting technology, as outlined in reports by the European Parliament and the UK House of Commons (Cath et al., 2017).

In the context of education, the EU's focus on AI regulation extends to ensuring that AI-based decisions, such as those affecting access to education or educational opportunities, are explainable and transparent to protect individuals from potential adverse effects (Khan et al., 2022). Additionally, European universities are considering the impact of game-changing technologies on primary and secondary education, mostly aiming to develop competent pre-service teachers who align with high-level policy guidelines (Lozano & Blanco, 2023; Moral-Sánchez et al. 2023). The EU's efforts to govern AI, as reflected in the AI Act, mark a significant step in addressing the governance of these innovative tools, including their application in education (Niet et al., 2021; Schmid et al., 2022). The EU's engagement in passionate debates and policy development since 2016 underscores its commitment to facilitating the socially beneficial development and use of AI while mitigating associated risks (Ulnicane,

2022). Also, the EU recognizes the transformative potential of AI and machine learning also in healthcare and emphasizes the importance of effective governance to ensure patient safety and public trust, a principle that can be extended to educational settings as well (Gilbert et al., 2023).

2. The rise of Artificial Intelligence in the learning landscape

The integration of AIEd is being driven by heavy investments from private companies and public-private partnerships, highlighting the increasing importance and potential of AI advancements in educational settings. Europe has made substantial efforts, with reports indicating that the continent spent up to 700 million euros on AI for robotics and public-private partnerships (Wang et al., 2021). Additionally, the European research and innovation funding program, Horizon Europe, has prioritized AI as one of the key enabling technologies (Lova et al., 2021; Ahern et al., 2022). Furthermore, the European Union High-Level Expert Group on Artificial Intelligence (AI-HLEG) has provided policy and investment recommendations for trustworthy AI, paving the way for a comprehensive, risk-based policy framework in Europe (Pelta et al., 2020).

The landscape of AI applications in education is diverse, ranging from personalized learning platforms to smart tutoring systems. For example, adaptive learning technologies use AI algorithms to tailor educational content to individual students' needs (Bozkurt et al., 2021), allowing for a more customized and effective learning experience. Furthermore, AI-powered grading systems can provide instant feedback to students (Calatayud et al., 2021), allowing for timely interventions and a better understanding of their progress. These examples illustrate how AI technologies revolutionize the traditional education system by offering dynamic and adaptive learning solutions. Similarly, the rise of AIEd promises not only to transform teaching and learning processes but also reshape administrative tasks (Gualdi & Cordella, 2021). Indeed, AI tools are capable to automate administrative duties, such as scheduling, data analytics, and overall school management, streamlining processes, and monitoring students' attendance (Abgarayan, 2023). By leveraging AI for administrative functions, educational institutions can allocate more time and resources to improving the quality of education delivery and student support services, ultimately creating a more conducive learning environment for all stakeholders involved.

3. Which concepts are driving the debate on the academic level?

To pinpoint the foremost publications within the EU member states it is necessary to construct a bibliographic inventory through the extraction of data from trustworthy databases that provide sophisticated refinement parameters. Consequently, Scopus was selected due to its well-known precision in filtering functionalities and transferable result examination.

The terms “artificial intelligence” AND “education” were concurrently scrutinized in title-abstract-keywords, limited to journals in English within the temporal boundary of 2020-2024. The database in question is included in SJR indices and, owing to their efficacious attributes for categorizing specific outcomes, it furnishes a spectrum of alternatives for the acquisi-

tion of relevant titles in diverse formats conducive to subsequent bibliographic scrutiny. The conceptual formulations “artificial intelligence” AND “education” were input into the search interface enclosed within double quotation marks with the intent to capture the bi-lexical phrase in its entirety. All filtering criteria are illustrated in *Table 1*.

| “Artificial Intelligence” AND “Education” {title-abstract-keywords} | Filtering criteria | | Records selected |
|--|--------------------|-----------------------|------------------|
| SCOPUS Items returned = 24,312 | TIMESPAN | 2020 – 2024 | 496 |
| | SOURCE TYPE | Journal article | |
| | SUBJECTS | Social Science | |
| | LANGUAGE | English | |
| | PUBLICATION STAGE | Final & In Press | |
| | COUNTRIES | Only EU Member States | |

Table 1. Filtering criteria applied to the search in Scopus.

Scopus results were afterward processed, according to the following steps to generate the keywords visualization in *Figure 1*:

1. The list of records was refined and extracted from Scopus in text format (*.csv).
2. The text format file (*.csv) was submitted to the txt2pajek.exe mapping algorithm (van Eck & Walt-

man, 2010) and processed to generate a Pajek (*.net) file.

3. A Pajek (*.net) file was saved and then imported into the social network analysis tool NetDraw.
4. In NetDraw, a selection of node centrality measures based on Degree Centrality was calculated to identify the keyword relatedness in the co-citation network.

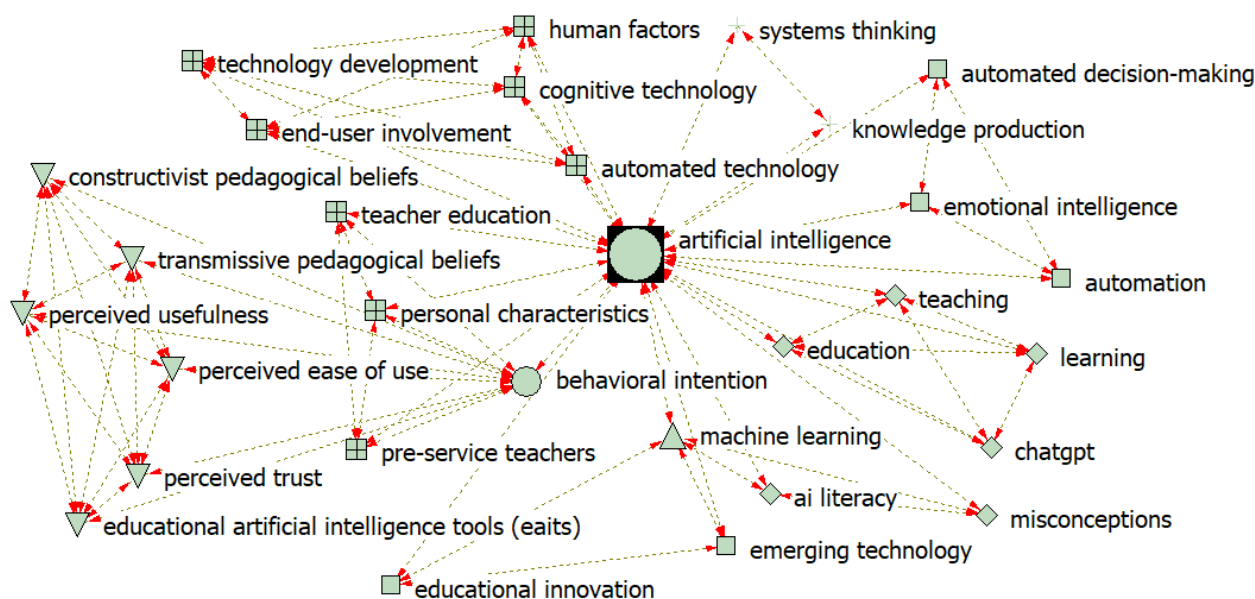


Figure 1. Map showing keywords associated with the 496 records retrieved from Scopus. Symbol value based on Degree Centrality: Circle in a Box = 27; Circle = 11; UpTriangle = 8; DownTriangle = 6; Box = 5; Diamond = 4; Square = 3; Plus = 2.

The association of keywords with scholarly articles, be it through author-assigned or indexed terms, constitutes the predominant method for identifying publications within a specified theme or academic discipline. Among the plethora of bibliometric methodologies available—such as co-citation and co-authorship analyses—the technique of keyword co-occurrence stands as one of the most dependable in unveiling the latent semantic architecture inherent in a corpus of scholarly work (Zhao et al., 2018). The process of delineating topics by examining a curated collection of papers risks neglecting the pervasive associations among particular key concepts and may overlook the manner in which semantic linkages forge connections between terms and ideas within an encompassed discipline. Conversely, the recurrent sharing of key terminologies amongst a community of scholars might disclose an underlying conceptual framework that is often more consistent than what might be inferred from mere observation of topical trends. Within network-centric bibliographic analysis, keywords themselves can function as nodes; thus, any

metrics employed for appraising nodes and their interconnections are effectively transformed into measures for assessing keyword prominence.

Degree Centrality is a metric that quantifies the prominence of a node within a network by counting the number of ties that connect it to other nodes. In the context of a directed network (where connections have arrows indicating their direction), this attribute can be bifurcated into two distinct measurements: In-Degree, which gauges the quantity of inbound links to a node, and OutDegree, which measures the number of outbound links from a node. When these principles are applied to a bibliometric network, the orientation of an arrow signifies citation directionality—indicating which author has cited whom. A double-headed arrow implies mutual citations between authors. As depicted in *Figure 2*, each node is annotated with its respective number of connections to adjacent nodes, and it is this count that intrinsically determines its hierarchical standing within the network.

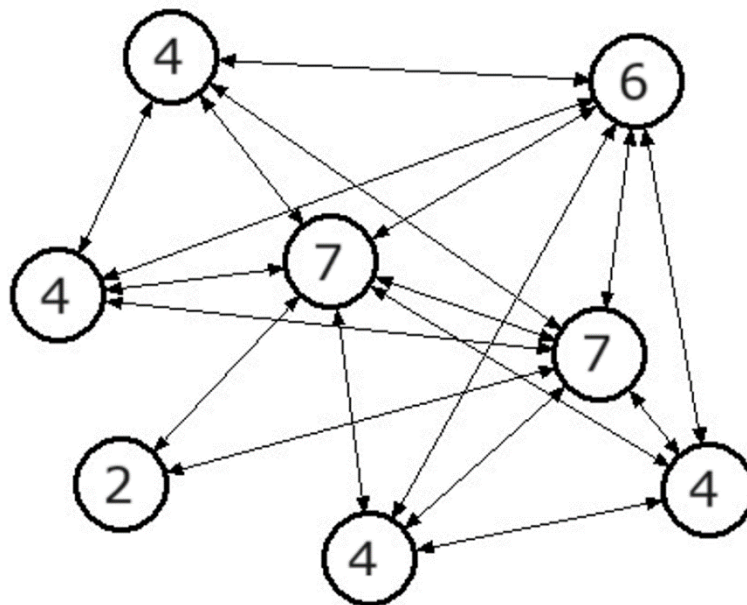


Figure 2. Visual representation of Degree Centrality.

Within the realm of bibliometrics, Degree Centrality is operationalized such that the frequency with which a keyword co-occurs with others (evidenced by the number of ties) elevates its rank or node weight within the network. Keywords attaining the highest ranks are those exhibiting the most extensive interlinking (ties) across the entire keyword landscape. Typically, these top-tier keywords mirror the principal subjects encapsulated by the curated selection of publications.

By selecting the publications sponsored by the European Commission, we reduced the initial sample of 496 papers to 32 titles which return a different set of keywords, as depicted in *Figure 3*. This network may better highlight what EU funding is prioritizing.

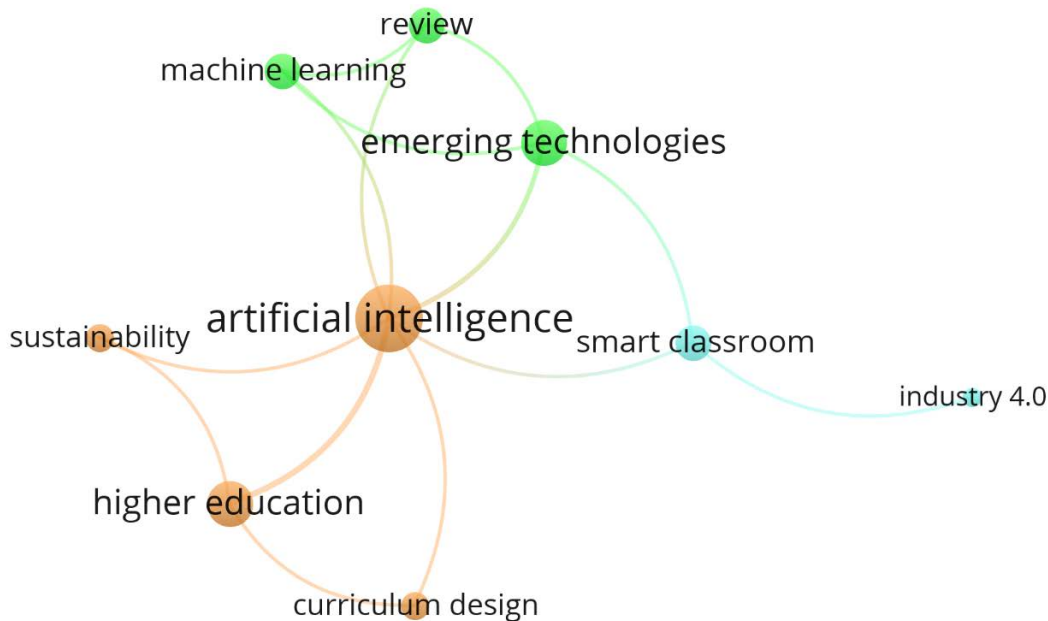


Figure 3. Keyword network extracted by the EU-sponsored publications.

4. The debate in the EU: main topics and gaps

Differently from what the keyword map may suggest, examining the most cited publications returns a scenario that is not centered on the implementation of AI solutions in classrooms. Contrary to what expected, not even the keywords *Industry 4.0*, *Sustainability* and *Machine Learning* are associated with scenarios of practical case studies. Indeed, the current debate emphasizes the need to ensure a trustworthy AI framework, as highlighted in the EU's reports, which underscore the importance of promoting public and private investments in AI, researching socio-economic changes, and establishing an ethical and legal framework to protect fundamental rights (Katuli, 2021). As way of example, the EU's sponsorship and support, along with initiatives from bodies such as the German chambers of commerce, have been instrumental in driving the implementation of VET in Europe (Rodríguez & Stendardi, 2023). However, concerns have been raised regarding data privacy and security in the context of AI implementation in education, as these systems rely on large volumes of student data for analysis and personalization (Kamalov et al., 2021). Nevertheless, there is a growing advocacy for the implementation of robust AI methodologies to uncover relationships among student learning variables and address issues related to graduate outcomes and student learning attributes in higher education (Deo et al., 2020). Competence-based curricula and qualifications are increasingly becoming strategic points in the agendas of national VET reforms, aiming to modernize VET curricula, improve access to learning, and enable progression through qualification levels (Ttlys & Spöttl, 2017; Gordon, 2015). VET has the potential to play a transformative role in reducing CO2 emissions and improving the energy efficiency of buildings across Europe, contributing to the broader societal and environmental goals (Clarke et al., 2020). Furthermore, the attractiveness of vocational training, as set in the Europe 2020

strategy, can be enhanced through a positive image of the VET sector (Ttlys et al., 2018). The European financial crisis has sparked a new enthusiasm for dual VET in Europe, with a focus on increasing the number of young people attaining post-compulsory educational qualifications and improving their employment opportunities (Pozo-Llorente & Vilches, 2020; Šepanovi & Artiles, 2020). The inclusion of vulnerable groups in VET has been a crucial focus, with efforts being made to promote equity and inclusion, particularly for individuals with a migration background or special education needs (Scharnhorst & Kammermann, 2020). The development of pedagogical competencies is also highlighted as a key objective in the implementation of competence-based VET curriculum reforms (Taccioni et al., 2021). The transferability of VET systems is a central issue within international comparative VET research, emphasizing the need for close cooperation between stakeholders and shared awareness for successful VET transfer (Li & Pilz, 2021; Honchar, 2022). Overall, the implementation of AI in VET presents opportunities for innovation and improvement in education, but it also requires careful consideration of ethical, privacy, and security concerns, as well as the need for inclusive and competency-based approaches.

The need for explainable AI and its relevance in adverse decisions affecting EU citizens is also underscored in European law, reflecting the emphasis on transparency and accountability in AI systems (Khan et al., 2022). Additionally, the scarcity of case studies suggesting real applications for AI in the public education within the European scenario is a point of concern, indicating a gap between AI's rapid progress and the technical stasis in education (Renz et al., 2020). The potential of AI to positively impact student success and enhance the learning needs of students was already recognized before it became a buzzword (Khare et al., 2018; How & Hung, 2019), while nowadays there is a growing discussion about introducing AI knowledge to K-12 students, attracting a wide range of stake-

holders and resources for school curriculum development (Dai et al., 2022). Additionally, the potential for AI to be integrated into technology education for middle school students is being explored, with deep implications for the curriculum (Park & Kwon, 2023). The impact of AI implementation in higher education is currently being studied on a theoretical level, with assumptions indicating that AI plays an efficient role in providing better education quality services and practical learning/teaching approaches for a better future career (Slimi, 2021). Likewise, the role and challenges of education for responsible AI are also being discussed, emphasizing the need for reform of traditional education systems in response to the social transformation brought about by this new technology (Dignum, 2021). There is also a call to integrate the *learning of ethics* alongside technical skills in AI courses and pathways, reflecting a growing awareness of the societal impacts of AI systems (Krakowski et al., 2022).

5. Impact on Teachers' Digital Skills

In the European context, the European Commission's Joint Research Centre (JRC) has highlighted the need for empirical evidence and case studies to inform policy decisions and investments in educational technology, including AI. The JRC's report on "Artificial Intelligence in Education" (Tuomi, 2018) emphasized the importance of showcasing successful AI applications in education through case studies to build confidence and understanding among stakeholders. To address the scarcity of case studies, it is essential for researchers, educational institutions, and edtech companies to collaborate on documenting and disseminating successful AI implementations in education. This could involve conducting in-depth case studies that capture the implementation process, challenges faced, and outcomes achieved. Additionally, professional organizations and educational networks can play a crucial role in facilitating the sharing of case studies and best practices in AI integration in education. The integration of AIED will significantly impact teachers' digital skills and professional growth. As AI technologies permeate educational settings, teachers are required to adapt to new tools and methodologies to enhance their teaching practices. For instance, AI-powered platforms can assist educators in analyzing student performance data, providing insights to tailor lesson plans according to individual student needs. This shift towards data-driven decision-making not only necessitates teachers to be proficient in using AI tools but also to interpret and apply the generated data effectively in the classroom. In addition, the incorporation of AIED is fostering the need for continuous professional development among teachers to stay abreast of technological advancements. Workshops and training sessions focusing on AI applications in education will likely become prevalent to equip educators with the necessary skills to leverage AI tools effectively. Many platforms already offers resources and consulting services to educators, facilitating the implementation of AI in teaching practices. These initiatives are not only enhancing teachers' digital competencies but also em-

powering them to create engaging and personalized learning experiences for students. By embracing AI technologies, teachers can establish a more interactive and adaptive learning environment that caters to diverse student needs, ultimately improving educational outcomes.

6. Ethical Considerations in AI Education

The rapid advancement of AI applications in higher education has sparked a critical discussion surrounding the ethical implications and risks associated with these technologies. Institutions are now under pressure to establish comprehensive frameworks for ethical governance in AI education to navigate the complex landscape of integrating this advanced technology responsibly. For example, the use of AI-powered proctoring systems in online exams raises concerns about privacy invasion and algorithmic bias, prompting educators to critically assess the ethical ramifications of such tools.

Consequently, as AI continues to permeate educational environments, researchers emphasize the significance of ethical considerations to maintain transparency, fairness, and accountability. By incorporating ethical principles into the design and deployment of AI systems, educators can ensure that students' rights and well-being are protected while leveraging the benefits of AI technologies in education. For instance, the implementation of AI-driven adaptive learning platforms necessitates thoughtful consideration of data privacy, algorithmic transparency, and the potential impact on student autonomy to uphold ethical standards in educational practices.

7. European Union's Initiatives in AI for Education

The EU is at the forefront of investing in AI to bolster Europe's competitiveness in the education sector. This strategic investment is evident in programs like Horizon Europe and Digital Europe, which commit €1 billion annually to AI initiatives, emphasizing the importance of this disrupting technology in shaping the future of education. The EU's dedication to AIED is further highlighted by the Recovery and Resilience Facility, which allocates €134 billion to digital advancements, with a focus on positioning Europe as a global leader in AI. These substantial financial commitments underscore the EU's recognition of AI as a transformative force in education, driving innovation and progress in the sector.

Furthermore, the European Commission's proactive approach involves collaborating with member states to formulate policies and investments that elevate the standards of AIED. By aligning national strategies and fostering cooperation, the EU is strengthening its position as a hub for AI excellence, paving the way for groundbreaking advancements in learning technologies. The EU's emphasis on a human-centric AI framework underscores its commitment to ethical and responsible AI practices in education, ensuring that learners benefit from inclusive and equitable educational experiences. Through

these collaborative efforts and strategic investments, the EU is poised to lead the way in harnessing the full potential of AI to enrich and transform educational landscapes across the continent.

In April 2018, in response to a request from the European Council to present a European approach to AI, the European Commission presented its AI strategy in the “Artificial Intelligence for Europe” (Pourzolfaghar et al., 2023). Additionally, the European Commission established an independent High-Level Expert Group on Artificial Intelligence (AI HLEG) in June 2018 to address the increasing ethical questions raised by AI technology (Smuha, 2019). It also reported that the EU utilized courses and resources online to nurture population-wide AI literacy, rather than designating students or subjects at specific school levels (Chiu et al., 2022). This approach indicates a concerted effort to democratize AIEd and make it accessible to a wider population.

Therefore, the European education system is also focusing on ethical considerations in AIEd. The European Commission’s ethical guidelines establish ethical principles based on the recognized fundamental rights that future AI systems need to adhere to in order to be recognized as trustworthy (Katuli, 2021). This emphasis on ethical guidelines reflects a commitment to ensuring that AIEd in European schools aligns with ethical standards and respects fundamental rights.

In summary, the European education system is responding to the integration of AIEd through the development of AI strategies, ethical guidelines, and efforts to democratize AI literacy. There is a growing recognition of the importance of AIEd in primary and secondary schools, with a focus on making AI knowledge accessible and optimizing the effectiveness of AI-based approaches.

8. Leveraging AI for Inclusive Education

UNESCO underscores the significance of a human-centered approach to AIEd, aiming to tackle disparities and promote inclusivity. By leveraging AI, educational institutions can enhance human capabilities, safeguard human rights, and facilitate efficient collaboration between humans and machines, contributing to sustainable development. For instance, AI-powered adaptive learning platforms can provide personalized educational experiences to students with diverse learning needs, ensuring that each learner receives tailored support to reach their full potential. The EU’s focus aligns with the potential of AI to contribute to changing education through personalized approaches, automation of administrative tasks, and intelligent use of data to support students (Hinojo-Lucena et al., 2019). Furthermore, the EU’s vision for AI, as outlined in the Artificial Intelligence Package, includes a general approach for AI and a proposal for dedicated regulations, demonstrating a comprehensive strategy for integrating AI into various sectors, including education (Niet, 2022). Additionally, AI can provide access to better learning opportunities for marginalized groups, such as people with disabilities and those living in isolated communities, aligning with the EU’s goal of promoting inclusive education

(Göçen & Aydemir, 2020). Moreover, AIEd has been recognized as advantageous, facilitating teaching and contributing to the quality of education (Dergunova et al., 2022). Therefore, the integration of AI in education can bridge gaps in access to quality learning opportunities, especially for marginalized groups. By leveraging AI technologies, educators can design inclusive learning environments that cater to the individual needs of all students, regardless of their backgrounds or abilities. For example, AI-driven assistive technologies can empower students with disabilities by providing them with customized tools and resources to aid their learning process, thereby fostering a more equitable educational landscape.

Additionally, partnerships play a pivotal role in harnessing the power of AI to promote inclusive education practices. Collaborative efforts between educational institutions, technology developers, and policymakers can drive innovation in creating AI solutions that address specific challenges faced by diverse student populations. By working together, stakeholders can ensure that AI advancements in education are ethically sound, culturally sensitive, and designed to benefit learners from all socio-economic backgrounds, ultimately contributing to the reduction of educational inequalities.

9. What is the future perspective of AIEd in the European Union?

The perspectives of AIEd in the EU for the future are multifaceted and encompass various dimensions, including ethical, regulatory, educational, and societal considerations. The European Commission has been proactive in formulating an AI strategy and establishing ethical guidelines to promote the responsible and trustworthy use of AI (Derave et al., 2022). This approach is aimed at fostering consumer confidence in AI products and harmonizing their adoption across the EU (Coppola et al., 2021). Additionally, the EU’s approach to Responsible AI (RAI) has been subject to scrutiny by law and policy scholars, highlighting the need for ongoing evaluation and refinement of AI governance frameworks (Minkkinen et al., 2022). The European Union’s emphasis on specific AI in digital education plans reflects a practical and applied perspective, aligning with recommendations for future educational initiatives (Bellás et al., 2022). Furthermore, the EU’s focus on ethical AI and participatory design of learning environments underscores a commitment to ethical considerations and the implications of AI in educational settings (Chounta et al., 2021).

From a regulatory standpoint, the EU has been actively engaged in addressing ethical and safety concerns related to AI, particularly in sectors such as healthcare and medical imaging (Pesapane et al., 2018). The EU’s efforts to ensure consistency with existing Union legislation and protect fundamental rights in the context of AI regulation demonstrate a forward-looking approach to AI governance (Cefaliello & Kullmann, 2022). Along with this, the EU’s commitment to a human-centric and trustworthy approach to AI reflects a proactive stance in addressing the societal and ethical implications of AI (Derave et

al., 2022). In the context of education, the EU's focus on AI literacy and the development of AI curriculum for high schools underscores a commitment to preparing future generations for the AI-driven digital era (Bellás et al., 2022).

10. Conclusion

This comprehensive analysis of AI integration in European education suggests a promising but complex future. On the one hand, AI is poised to transform the educational landscape significantly, providing more personalized and adaptive learning experiences for students. The ability of AI to personalize instruction, provide real-time feedback, automate administrative tasks, and even potentially reduce educational disparities, positions it as a critical tool for enhancing education at all levels. The emphasis on continuous professional development among teachers also suggests that the future of education will necessitate educators who are not only subject-matter experts but also technological facilitators. This will reasonably lead to a deep overhaul in teacher training programs and a revision of upskilling and reskilling needs for in-service educators. On the other hand, the integration of AI into education presents significant challenges related to ethics, privacy protection, governance regulation, and legislative measures which have all been underscored in this analysis. Ensuring transparency in AI decision-making processes within an educational context is emphasized as being crucial. While the potential benefits of integrating AI into European education are vast, substantial efforts regarding ethical considerations and regulatory measures must be made consistently by all stakeholders involved: policymakers, educators, families, students, and private entities alike. In conclusion, while there is growing interest in integrating AI into European classrooms, there are challenges that need to be addressed, including the lack of case studies focusing on daily integration, the need for teacher training, and the critical questions and potential obstacles associated with this technological shift.

References

- Abgaryan, H., Asatryan, S., & Matevosyan, A. (2023). Revolutionary changes in higher education with artificial intelligence. *Main Issues of Pedagogy and Psychology*, 10(1), 76-86. <https://doi.org/10.24234/miopap.v10i1.454>
- Ahern, M., O'Sullivan, D., & Bruton, K. (2022). Development of a framework to aid the transition from reactive to proactive maintenance approaches to enable energy reduction. *Applied Sciences*, 12(13), 6704. <https://doi.org/10.3390/app12136704>
- Bellás, F., Guerreiro-Santalla, S., Naya-Varela, M., & Duro, R. (2022). AI curriculum for European high schools: an embedded intelligence approach. *International Journal of Artificial Intelligence in Education*, 33(2), 399-426. <https://doi.org/10.1007/s40593-022-00315-0>
- Bozkurt, A., Karadeniz, A., Bañeres, D., & Rodríguez, M. E. (2021). Artificial intelligence and reflections from educational landscape: a review of AI studies in half a century. *Sustainability*, 13(2), 800. <https://doi.org/10.3390/su13020800>
- Calatayud, V. G., Espinosa, M. P. P., & Vila, R. R. (2021). Artificial intelligence for student assessment: a systematic review. *Applied Sciences*, 11(12), 5467. <https://doi.org/10.3390/app11125467>
- Cath, C., Wächter, S., Mittelstadt, B., Taddeo, M., & Floridi, L. (2017). Artificial Intelligence and the 'good society': The US, EU, and UK approach. *Science and Engineering Ethics*. <https://doi.org/10.1007/s11948-017-9901-7>
- Chiu, T. and Chai, C. (2020). Sustainable curriculum planning for artificial intelligence education: a self-determination theory perspective. *Sustainability*, 12(14), 5568. <https://doi.org/10.3390/su12145568>
- Chounta, I., Bardone, E., Raudsep, A., & Pedaste, M. (2021). Exploring teachers' perceptions of artificial intelligence as a tool to support their practice in estonian k-12 education. *International Journal of Artificial Intelligence in Education*, 32(3), 725-755. <https://doi.org/10.1007/s40593-021-00243-5>
- Clarke, L., Sahin-Dikmen, M., & Winch, C. (2020). Overcoming diverse approaches to vocational education and training to combat climate change: the case of low energy construction in Europe. *Oxford Review of Education*, 46(5), 619-636. <https://doi.org/10.1080/03054985.2020.1745167>
- Coppola, F., Faggioni, L., Gabelloni, M., Vietro, F., Mendola, V., Cattabriga, A., ... & Golfieri, R. (2021). Human, all too human? an all-around appraisal of the "artificial intelligence revolution" in medical imaging. *Frontiers in Psychology*, 12. <https://doi.org/10.3389/fpsyg.2021.710982>
- Dai, Y., Liu, A., Jian-jun, Q., Guo, Y., Jong, M., Chai, C., ... & Lin, Z. (2022). Collaborative construction of artificial intelligence curriculum in primary schools. *Journal of Engineering Education*, 112(1), 23-42. <https://doi.org/10.1002/jee.20503>
- Deo, R., Yaseen, Z., Al-Ansari, N., Nguyen-Huy, T., Langlands, T., & Galligan, L. (2020). Modern artificial intelligence model development for undergraduate student performance prediction: an investigation on engineering mathematics courses. *Ieee Access*, 8, 136697-136724. <https://doi.org/10.1109/access.2020.3010938>
- Derave, C., Genicot, N., & Hetmanska, N. (2022). The risks of trustworthy artificial intelligence: the case of the European travel information and authorisation system. *European Journal of Risk Regulation*, 13(3), 389-420. <https://doi.org/10.1017/err.2022.5>
- Dergunova, Y., Aubakirova, R., Yelmuratova, B., Gulmira, T., Yuzikovna, P., & Antikeyeva, S. (2022). Artificial intelligence awareness levels of students. *International Journal of Emerging Technologies in Learning (IJET)*, 17(18), 26-37. <https://doi.org/10.3991/ijet.v17i18.32195>
- Dignum, V. (2021). The role and challenges of education for responsible AI. *London Review of Education*, 19(1). <https://doi.org/10.14324/lre.19.1.01>
- European Commission. (2021, April 21). ANNEXES to the Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions Fostering a European approach to Artificial Intelligence: Coordinated Plan on Artificial Intelligence 2021 Review (COM(2021) 205 final). Brussels.
- European Commission. (2022). Directorate-General for Education, Youth, Sport and Culture, Ethical guidelines on the use of artificial intelligence (AI) and data in teaching and learning for educators. Luxembourg: Publications Office of the European Union. <https://data.europa.eu/doi/10.2766/153756>
- Franklin, M., Ashton, H., Gorman, R., & Armstrong, S. (2022). Missing mechanisms of manipulation in the EU AI Act. *The International Flairs Conference Proceedings*, 35. <https://doi.org/10.32473/flairs.v35i.130723>
- Gilbert, S., Anderson, S., Daumer, M., Li, P., Melvin, T., & Williams, R. (2023). Learning from experience and finding the right balance in the governance of artificial intelligence and digital health technologies. *Journal of Medical Internet Research*, 25, e43682. <https://doi.org/10.2196/43682>

- Göçen, A. and Aydemir, F. (2020). Artificial intelligence in education and schools. *Research on Education and Media*, 12(1), 13-21. <https://doi.org/10.2478/rem-2020-0003>
- Gordon, J. (2015). Glimpsing the future in the past: vet in Europe. *European Journal of Education*, 50(4), 440-460. <https://doi.org/10.1111/ejed.12151>
- Gualdi, F. and Cordella, A. (2021). Artificial intelligence and decision-making: the question of accountability. *Proceedings of the Annual Hawaii International Conference on System Sciences*. <https://doi.org/10.24251/hicss.2021.281>
- Hinojo-Lucena, F., Díaz, I., Cáceres-Reche, M., & Rodríguez, J. (2019). Artificial intelligence in higher education: a bibliometric study on its impact in the scientific literature. *Education Sciences*, 9(1), 51. <https://doi.org/10.3390/educsci9010051>
- Honchar, L. (2022). The main challenges of dual vocational education and training system transfer. *Education Modern Discourses*, (5), 110-117. <https://doi.org/10.37472/2617-3107-2022-5-08>
- How, M. and Hung, D. (2019). Educational stakeholders' independent evaluation of an artificial intelligence-enabled adaptive learning system using Bayesian network predictive simulations. *Education Sciences*, 9(2), 110. <https://doi.org/10.3390/educsci9020110>
- Kamalov, F., Thabtah, F., & Gurrub, I. (2021). Autocorrelation for time series with linear trend. *2021 International Conference on Innovation and Intelligence for Informatics, Computing, and Technologies (3ICT)*. <https://doi.org/10.1109/3ict53449.2021.9581809>
- Katuli, T. (2021). Towards the trustworthy ai. *Medijska Istraživanja*, 26(2), 9-28. <https://doi.org/10.22572/mi.26.2.1>
- Khan, M. S., Nayebpour, M., Li, M., El Amine, H., Koizumi, N., & Olds, J. L. (2022). Explainable ai: a neurally-inspired decision stack framework. *Biomimetics*, 7(3), 127. <https://doi.org/10.3390/biomimetics7030127>
- Khare, K., Stewart, B., & Khare, A. (2018). Artificial intelligence and the student experience: an institutional perspective. *IAFOR Journal of Education*, 6(3), 63-78. <https://doi.org/10.22492/ije.6.3.04>
- Krakowski, A., Greenwald, E., Hurt, T., Nonnecke, B., & Cannady, M. (2022). Authentic integration of ethics and ai through sociotechnical, problem-based learning. *Proceedings of the AAAI Conference on Artificial Intelligence*, 36(11), 12774-12782. <https://doi.org/10.1609/aaai.v36i11.21556>
- Li, J. and Pilz, M. (2021). International transfer of vocational education and training: a literature review. *Journal of Vocational Education and Training*, 75(2), 185-218. <https://doi.org/10.1080/13636820.2020.1847566>
- Lova, J. G., Bueno-Delgado, M. V., Cañavate-Cruzado, G., & Garrido-Lova, J. (2021). Twin transition through the implementation of industry 4.0 technologies: desk-research analysis and practical use cases in Europe. *Sustainability*, 13(24), 13601. <https://doi.org/10.3390/su132413601>
- Lozano, A.; Blanco Fontao, C. (2023). Is the Education System Prepared for the Irruption of Artificial Intelligence? A Study on the Perceptions of Students of Primary Education Degree from a Dual Perspective: Current Pupils and Future Teachers. *Educ. Sci.*, 13(7), 33. <https://doi.org/10.3390/educsci13070733>
- Minkkinen, M., Zimmer, M., & Mäntymäki, M. (2022). Co-shaping an ecosystem for responsible ai: five types of expectation work in response to a technological frame. *Information Systems Frontiers*, 25(1), 103-121. <https://doi.org/10.1007/s10796-022-10269-2>
- Moral-Sánchez, S. N., Ruiz Rey, F. J., & Cebrián-de-la-Serna, M. (2023). Analysis of artificial intelligence chatbots and satisfaction for learning in mathematics education. *IJERI: International Journal of Educational Research and Innovation*, (20), 1-14. <https://doi.org/10.46661/ijeri.8196>
- Niet, I. (2022). Between vision and practice: lack of alignment between ai strategies and energy regulations in the dutch electricity sector. *Discover Artificial Intelligence*, 2(1). <https://doi.org/10.1007/s44163-022-00040-6>
- Niet, I., Est, R., & Veraart, F. (2021). Governing ai in electricity systems: reflections on the eu artificial intelligence bill. *Frontiers in Artificial Intelligence*, 4. <https://doi.org/10.3389/frai.2021.690237>
- Park, W. and Kwon, H. (2023). Implementing artificial intelligence education for middle school technology education in republic of Korea. *International Journal of Technology and Design Education*, 34, 109-135. <https://doi.org/10.1007/s10798-023-09812-2>
- Pelta, D. A., Verdegay, J. L., Lamata, M. T., & Corona, C. C. (2020). Trust dynamics and user attitudes on recommendation errors: preliminary results. *arXiv*. <https://doi.org/10.48550/arxiv.2002.04302>
- Pesapane, F., Volonté, C., Codari, M., & Sardanelli, F. (2018). Artificial intelligence as a medical device in radiology: Ethical and regulatory issues in Europe and the United States. *Insights Into Imaging*, 9(5), 745-753. <https://doi.org/10.1007/s13244-018-0645-y>
- Pozo-Llorente, M. and Vilches, M. (2020). Conditioning factors of sustainability of dual vocational educational training in Andalusia (Spain): Case study of three educational centres. *Sustainability*, 12(22), 9356. <https://doi.org/10.3390/su12229356>
- Renz, A., Krishnaraja, S., & Gronau, E. (2020). Demystification of artificial intelligence in education – how much ai is really in the educational technology?. *International Journal of Learning Analytics and Artificial Intelligence for Education (IJAI)*, 2(1), 14. <https://doi.org/10.3991/ijai.v2i1.12675>
- Rodríguez, J. and Stendardi, D. (2023). The implementation of dual vocational education and training in Spain: analysis of company tutors in the tourism sector. *International Journal for Research in Vocational Education and Training*, 10(1), 90-112. <https://doi.org/10.13152/ijrvet.10.1.5>
- Šepanovi, V. and Artilas, A. (2020). Dual training in europe: a policy fad or a policy turn?. *Transfer European Review of Labour and Research*, 26(1), 15-26. <https://doi.org/10.1177/1024258919898317>
- Scharnhorst, U. and Kammermann, M. (2020). Who is included in vet, who not?. *Education + Training*, 62(6), 645-658. <https://doi.org/10.1108/et-11-2019-0248>
- Schmid, S., Riebe, T., & Reuter, C. (2022). Dual-use and trustworthy? A mixed methods analysis of ai diffusion between civilian and defense R&D. *Science and Engineering Ethics*, 28(2). <https://doi.org/10.1007/s11948-022-00364-7>
- Slimi, Z. (2021). The impact of ai implementation in higher education on educational process future: a systematic review. *Research Square*. <https://doi.org/10.21203/rs.3.rs-1081043/v1>
- Smuha, N. (2019). The EU approach to ethics guidelines for trustworthy Artificial Intelligence. *Computer Law Review International*, 20(4), 97-106. <https://doi.org/10.9785/cril-2019-200402>
- Tacconi, G., T tlys, V., Perini, M., & Gedvilien, G. (2021). Development of pedagogical competencies of the vocational teachers in Italy and Lithuania: Implications of competence-based vet curriculum reforms. *European Journal of Training and Development*, 45(6/7), 526-546. <https://doi.org/10.1108/ejtd-03-2020-0041>
- Tuomi, I. (2018). The Impact of Artificial Intelligence on Learning, Teaching, and Education. In M. Cabrera, R. Vuorikari, & Y. Punie (Eds.), *Policies for the future* (EUR 29442 EN). Luxembourg: Publications Office of the European Union. <https://doi.org/10.2760/12297>
- T tlys, V. and Spöttl, G. (2017). From the analysis of work-processes to designing competence-based occupational standards and vocational curricula. *European Journal of Training and Development*, 41(1), 50-66. <https://doi.org/10.1108/ejtd-10-2015-0078>
- T tlys, V., Gedvilien, G., & Vaiciukyniene, S. (2018). Legal regulations for advertising vocational education and training services: case study of Lithuania. *European Scientific Journal ESJ*, 14(22), 202. <https://doi.org/10.19044-esj.2018.v14n22p202>

- Ulnicane, I. (2022). 'Emerging technology for economic competitiveness or societal challenges? Framing purpose in Artificial Intelligence policy', *Global Public Policy and Governance*, 2(3), 326-345. <https://doi.org/10.1007/s43508-022-00049-8>
- Wang, C., Teo, T. S. H., & Janssen, M. (2021). Public and private value creation using artificial intelligence: an empirical study of ai voice robot users in Chinese public sector. *International Journal of Information Management*, 61, 102401. <https://doi.org/10.1016/j.ijinfomgt.2021.102401>
- Zalite, G. and Zvirbule, A. (2020). Digital readiness and competitiveness of the eu higher education institutions: the covid-19 pandemic impact. *Emerging Science Journal*, 4(4), 297-304. <https://doi.org/10.28991/esj-2020-01232>
- Zhao, W., Mao, J., & Lu, K. (2018). Ranking themes on co-word networks: Exploring the relationships among different metrics. *Information Processing & Management*, 54(2), 203–218. <https://doi.org/10.1016/j.ipm.2017.11.005>