Latest updates: https://dl.acm.org/doi/10.1145/3688671.3688781

RESEARCH-ARTICLE

Trustworthy AI in education: A Roadmap for Ethical and Effective Implementation

EVANGELIA ANAGNOSTOPOULOU, National Technical University of Athens (NTUA), Athens, Attica, Greece

NIKOLAOS ANTONIOS GRAMMATIKOS, National Technical University of Athens (NTUA), Athens, Attica, Greece

DIMITRIS APOSTOLOU, University of Piraeus, Piraeus, Attica, Greece

GREGORIS N MENTZAS, National Technical University of Athens (NTUA), Athens, Attica, Greece

Trustworthy AI in education: A Roadmap for Ethical and Effective Implementation

Evangelia Anagnostopoulou
Institute of Communication and Computer Systems,
National Technical University of Athens
GR
eanagn@mail.ntua.gr

Nikolaos Antonios Grammatikos
Institute of Communication and Computer Systems,
National Technical University of Athens
GR
ngrammatikos@mail.ntua.gr

Dimitris Apostolou
University of Piraeus
GR
dapost@unipi.gr

Gregoris Mentzas
National Technical University of Athens
GR
gmentzas@mail.ntua.gr

Abstract

The integration of artificial intelligence (AI) into educational systems has the potential to revolutionize teaching and learning processes, offering personalized experiences, adaptive assessments, and administrative efficiency. However, ensuring trust in AI-based education is essential for its successful implementation. This research paper explores the importance of AI in education and identifies challenges to trustworthiness based on the Assessment List for Trustworthy Artificial Intelligence (ALTAI). Drawing on this analysis, the paper proposes strategies for promoting trust in AI-driven education. By addressing these challenges and implementing the proposed strategies, educational institutions can build an environment of trust, transparency, and accountability in AI-driven education.

CCS Concepts

• **Artificial intelligence**;

Keywords

Artificial intelligence, Education, Trustworthy AI, Ethic

1 Introduction

Artificial intelligence (AI) has emerged as a powerful tool in education, offering innovative solutions to enhance the teaching and learning processes. From personalized learning experiences to administrative efficiency, AI technologies have the power to reshape the educational landscape. However, their successful integration in education requires building trust among stakeholders, including teachers, students, parents, and policymakers. Trust is vital to ensure the ethical and effective implementation of AI-driven educational initiatives, mitigating concerns related to bias, privacy, and transparency.

The ethical use of AI in education presents various risks and challenges, emphasizing the need for clear guidelines to ensure trustworthiness. Many studies propose different ethical theories, each offering specific guidance for AI development and use [1],[2]. A review and analysis of the current state of trustworthy AI [3] provides an overview of the properties of trustworthy AI, along with the related principles and standards. While various studies propose different guidelines for trustworthy AI, the European Union's Assessment List for Trustworthy Artificial Intelligence (ALTAI) tool, developed by the High-Level Expert Group on Artificial Intelligence (AI-HLEG), stands out for its ability to help organizations in evaluating the trustworthiness of their AI systems [4]. This paper explores the significance of AI in education while identifying challenges related to trustworthiness using the ALTAI framework.

The paper is organized as follows. Section 2 explores the significance of AI in education, emphasizing its potential to revolutionize teaching and learning methods, enhance personalized learning experiences and enable data-driven decision-making. Section 3 explores the challenges of ensuring trustworthiness in AI-driven education, drawing upon the Assessment List for Trustworthy Artificial Intelligence (ALTAI). This section addresses concerns related to bias, privacy, transparency, and ethical considerations, underscoring the importance of mitigating these challenges to foster trustworthiness among stakeholders. Section 4 proposes a roadmap comprising strategies for ensuring trust in AI-driven education. By addressing these challenges and implementing the proposed strategies, educational institutions can provide an environment of trust, transparency, and accountability in AI-driven educational ecosystems, facilitating the ethical and effective integration of AI technologies in education.

Table 1: Challenges in the ALTAI Framework for Trustworthy AI in Education

Aspect	Challenges in education
Technical robustness and safety	Mitigating risks of AI system malfunction or error leading to harm to students or educators
	Securing educational systems against cyber threats and preventing unauthorized access.
	Ensuring accuracy and reliability in AI driven decision-making
Privacy and Data governance	Protecting the privacy of student data used by AI systems
	Implementing robust anonymization techniques safeguards student privacy rights.
Diversity and Fairness	Ensuring equitable access to AI technologies across different socio-economic backgrounds.
	Risks of language bias in AI-driven content or assessments.
	Support for students with diverse learning abilities and disabilities.
Transparency	AI models work as 'black boxes', indicating that their mechanisms are not understandable by humans.
	Lack of transparency in group formation.
Sustainability	Overemphasizing easily measurable skills while ignoring critical aspects such as creativity.
	Significant energy consumption and environmental impact of AI systems in education.
Accountability	The complexity of AI systems complicates defining clear lines of accountability among stakeholders.
	Implementing effective auditing and oversight mechanisms faces obstacles.
Human agency& oversight	Maintaining human autonomy in AI education.
	Risk of reducing student autonomy and agency in the learning process.

2 SIGNIFICANCE OF TRUSTWORTHINESS IN AI FOR EDUCATION

AI can address various challenges in education and unlock new opportunities for improving learning outcomes. However, the extensive adoption of AI in educational settings necessitates a critical consideration of its trustworthiness. Trustworthy AI in education not only ensures ethical and responsible deployment but also builds an environment useful for effective learning and development.

The applications of AI in education can be categorized into four use cases [5]. Firstly, AI acts as an instructor, sharing knowledge and skills with learners. Also, it supports students by providing personalized learning experiences tailored to individual needs. By analyzing large data sets, AI identifies learning patterns and offers adaptive strategies, resulting in targeted interventions and resources that enhance academic performance and overall learning outcomes [6].

AI also empowers teachers by increasing their capabilities and efficiency. AI-driven tools facilitate automated grading and content creation, enabling educators to allocate more time to personalized instruction [7]. Moreover, AI-based analytics offer valuable insights into student progress and engagement, supporting educators and tailoring their teaching strategies accordingly [8]. Lastly, AI contributes to systemic improvements in education by enabling diagnostic assessments, predictive analytics, and system-wide planning initiatives. Through diagnostic assessments, teachers can gain deeper insights into students' strengths, and weaknesses, facilitating targeted interventions and personalized learning experiences [9]. Moreover, predictive analytics further enhance educational efficacy by identifying at-risk students and recommending measures to improve retention and academic success rates [10].

Despite the potential benefits of AI in education, there are significant challenges related to trustworthiness that must be addressed.
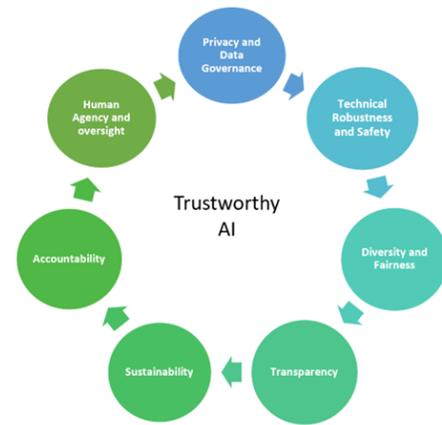

Figure 1: Requirements for a trustworthy AI system

In the following section, we will discuss these challenges based on the ALTAI framework.

3 CHALLENGES in Implementing Trustworthy AI in Education

The increasing use of AI technologies in education results in concerns regarding their ethical use, accountability, and transparency. To effectively manage these concerns, it is crucial to adopt a comprehensive framework that addresses the various dimensions of trustworthy AI. The ALTAI framework provides a structured methodology, comprising seven essential aspects [4]. Figure 1 presents the key requirements for a Trustworthy AI system.

Table 1 provides an overview of the challenges associated with each aspect of the ALTAI framework for trustworthy AI in education. The remaining of this section outlines these challenges and aligns them with the ALTAI framework for trustworthiness, based on European guidelines.

3.1 Privacy and Data Governance

One of the primary concerns surrounding AI in education is the privacy and security of student data. The increasing utilization of AI in educational settings raises critical concerns regarding data protection and privacy rights. While privacy and data protection have long been recognized as fundamental rights in EU law, the arrival of AI in education has heightened these concerns due to the extensive amount of data required for its functioning.

During both the training and operational phases, AI in education applications rely heavily on student data, including academic performance, and personal characteristics. This data is utilized to personalize learning pathways, assess student abilities, and provide tailored educational tools. However, the collection and analysis of such comprehensive student data carry significant privacy implications and ethical considerations [11].

A key challenge lies in ensuring compliance with privacy regulations, such as the General Data Protection Regulation (GDPR) in the European Union. These regulations require strict guidelines for collecting, storing, and utilizing student data, including data obtained through AI systems. Compliance with these regulations requires educational institutions to establish robust data management practices, including obtaining informed consent from students or their parents regarding data collection and usage.

Another crucial aspect in safeguarding student privacy rights within AI-driven educational systems is the anonymization of data. Anonymization involves the process of removing personally identifiable information from datasets, thereby minimizing the risk of individuals being identified or their privacy compromised. By anonymizing data, educational institutions can protect the privacy of students while still leveraging valuable insights for improving learning experiences and educational outcomes. However, it is essential to recognize that anonymization is not foolproof, and re-identification risks may still exist [12]. Therefore, alongside anonymization, continuous monitoring and evaluation of data privacy measures are essential to mitigate potential privacy risks effectively.

3.2 Technical robustness and safety

Ensuring the safety and robustness of AI systems in educational settings is essential to prevent potential harm to students and educators. While AI holds tremendous promise for enhancing learning experiences, overlooking the technical infrastructure and robustness of these systems can lead to various types of harm.

The integration of AI systems in educational environments introduces vulnerabilities that can be exploited by cyber threats and attacks. AI algorithms rely on vast amounts of data, making them susceptible to data breaches if not adequately protected. Additionally, adversarial attacks can manipulate AI models by injecting malicious data or exploiting vulnerabilities in the algorithms themselves [4]. These attacks can result in compromised student data,

inaccurate learning outcomes, or even the manipulation of educational content. Furthermore, the increasing sophistication of AI technologies poses challenges in detecting and mitigating emerging cyber threats, highlighting the need for robust cybersecurity measures in educational institutions.

Securing educational systems against cyber threats and preventing unauthorized access presents significant challenges for educational institutions. Educational institutions frequently meet limitations in resources, making it challenging to implement comprehensive cybersecurity measures. Addressing these challenges requires a multi-layered approach that encompasses risk assessment, access controls, encryption, user training, and collaboration with cybersecurity experts to safeguard educational systems against cyber threats and unauthorized access.

Technical robustness also encompasses the system's ability to make accurate judgments [13]. Inaccurate decisions, predictions, or recommendations by AI systems can have negative consequences in education, such as providing incorrect content recommendations, evaluating students or teachers erroneously, or delivering inaccurate feedback. For example, early warning systems that analyze student profiles to identify those at risk of dropping out, face the risk of making inaccurate predictions if their effectiveness in identifying the correct students is too restricted [14].

3.3 Diversity and fairness

One significant challenge faced by AI in recommending educational materials lies in the potential for reinforcing existing biases in education. For example, if an AI agent recommends materials only in English without translations, non-native English speakers are disadvantaged, limiting their access to education. This reinforces existing disparities and excludes diverse perspectives, reducing the effectiveness of education initiatives. Therefore, it's crucial to address these biases to ensure fair access to educational resources for all students, regardless of language or cultural background.

Disparities in access to AI technologies and educational resources often correlated with socioeconomic status can widen existing inequalities in education. For instance, a study shed light on this issue by revealing that students from low-income backgrounds meet considerable difficulties in accessing both the internet and supplementary learning materials outside of school compared to their wealthier peers [15]. This discrepancy underscores the impact of socioeconomic factors on educational access, with students from poor backgrounds facing challenges in accessing the essential tools and resources necessary. Such findings highlight the urgent need for targeted interventions and equitable distribution of resources to address these systemic inequalities and ensure that all students, regardless of socioeconomic background, have equal opportunities to pursue and succeed in education.

Another significant challenge in education is the utilization of advanced textbooks or resources without sufficient support for students with diverse learning abilities. For instance, recommending complex textbooks or resources without adequate explanations can exclude students who require additional assistance. This lack of support maintains educational inequalities and diminishes accessibility for students with varying learning needs. Thus, addressing this challenge is crucial to promote equity in education by ensuring

that all students receive the necessary support to succeed regardless of their learning abilities.

Students with disabilities face various challenges that limit their access in STEM education [16]. These obstacles include the absence of mentors within their specific disability spectrum, inaccessible laboratory facilities, and the prevalence of negative attitudes from instructors and peers. All these constraints create formidable barriers for students with disabilities, limiting their access to STEM education. Thus, AI learning companion systems that recommend educational resources without considering the diverse needs of students with disabilities may reinforce biases against students with disabilities.

3.4 Transparency

While the integration of AI tools into education has led to notable advancements in learning and teaching methodologies [17], obstacles remain concerning the transparency of data usage. Transparency is required in how data is utilized within AI systems in education, as highlighted by Larsson & Heintz (2020) [18]. Cope & Kalantzis (2019) [19] emphasize the importance of transparency for educators and students, as data visualization provides insights into learner behavior and facilitates additional support from educators.

The idea of explainability in AI and data is crucial for promoting transparency within educational systems. It involves clarifying the operations of AI systems and the reasoning behind their decisions, ensuring stakeholders can comprehend and trust the outcomes [20]. However, some AI models work as 'black boxes', indicating that their internal workings are not readily understandable by humans. This lack of transparency can erode trust in the AI tools, as educators and students may be hesitant to rely on recommendations without understanding how they were generated.

One of the uses of AI in education is to provide intelligent support for collaborative learning [21]. For example, adaptive group formation takes advantage of AI techniques to tailor groupings according to individual students' characteristics [22]. However, the lack of transparency in group formation algorithms poses a significant challenge, casting doubt on the fairness and effectiveness of these groupings. As AI algorithms increasingly shape student groups based on criteria like academic performance, the absence of transparency raises concerns about potential biases. Thus, addressing transparency issues in group formation algorithms is paramount to ensuring fairness in AI-driven learning environments.

3.5 Sustainability

The integration of Artificial Intelligence systems in education brings significant challenges regarding sustainability. Rather than adapting to meet the diverse needs of learners, AI systems often shape the educational environments [23]. AI systems primarily rely on quantifiable data such as students' grades and progress reports to fuel their algorithms. In addition, the use of standardized metrics and assessments simplifies data analysis for AI systems, potentially leading educational institutions to prioritize standardized testing to optimize AI effectiveness. Consequently, there is a risk of overemphasizing easily measurable skills while ignoring critical aspects such as teamwork, communication, and creativity, which are vital for students' future success [24].

Moreover, the environmental sustainability of AI systems in education poses significant challenges. Many AI applications in educational settings require extensive processing and storage of data, resulting in significant energy consumption and environmental impact [25]. The energy-intensive nature of AI systems not only undermines their long-term sustainability but also contributes to environmental pollution. Addressing these challenges necessitates proactive measures to minimize the environmental footprint of AI systems in education, aligning with broader efforts toward environmental sustainability.

3.6 Accountability

Accountability is a foundational principle in ensuring the responsible deployment and use of AI systems in education. It demands that individuals take responsibility for the outcomes and consequences of AI systems. However, achieving accountability in educational AI presents several challenges. The complexity of AI systems in education presents challenges in clearly assigning responsibility [26]. To be accountable, developers and operators of AI systems should be capable of providing justification regarding the system's behavior and the resulting outcomes [27].

A fundamental aspect facilitating accountability is the auditability of AI in education systems. Auditability refers to the capability of assessing and evaluating the design process, algorithms, and data of a system, not only by internal auditors but also by external parties [8]. Implementing effective auditing and oversight mechanisms for AI systems in education presents challenges. Ensuring that AI in education systems is auditable requires technical expertise, resources, and cooperation from all stakeholders. Moreover, independent oversight of the auditing process may face obstacles.

3.7 Human Agency and oversight

AI in education presents significant challenges related to human agency. While AI agents aim to provide valuable support and recommendations to individuals, they also introduce external influences that can impact learners' cognitive biases and emotions, potentially undermining intrinsic motivation [28]. The design and operation of AI in education must navigate the delicate balance between assistance and autonomy. Challenges arise in ensuring that AI systems avoid disseminating misleading information, respect users' autonomy in cultivating independent thoughts, and safeguard against negative effects on users' emotions and social well-being. Therefore, careful attention must be paid to the ethical and pedagogical implications of AI integration in education to mitigate these potential risks and maintain the integrity of the learning experience.

Moreover, intelligent tutoring systems (ITS) leverage experts' knowledge to provide personalized learning experiences for students, mapping out learning materials and activities based on individual needs and misconceptions [29]. However, as AI systems increasingly make automated decisions, there is a risk of decreasing student autonomy and agency in the learning process. In addition, AI algorithms in education heavily rely on vast amounts of data to make predictions regarding student performance and to identify students at risk of discontinuing their educational journey. However, there is a risk of these predictions being inaccurate, necessitating
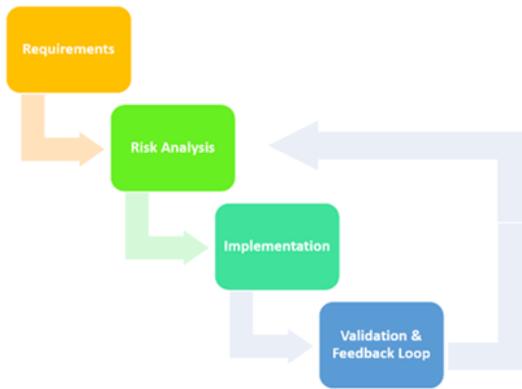
Figure 2: Roadmap for trustworthy AI in education.

human intervention to validate and make final decisions. Therefore, it becomes essential to maintain human oversight in AI implementation in education to prevent unexpected consequences [30]. The integration of human-in-the-loop AI applications is important in the development of trustworthy educational AI tools [31].

4 Strategies for Ensuring Trust in AI-Driven Education

4.1 RoadMap

There are many approaches to ensure the trustworthiness of AI systems. One of them is the AI Risk Management Framework (AI RMF 1.0) proposed by the National Institute of Standards and Technology (NIST) [32], which promotes the responsible design, development, deployment, and use of AI systems over time. Another approach is CapAI [33], a procedure for conducting the assessment of AI systems in line with the EU Artificial Intelligence Act. However, trustworthy AI in education demands a roadmap that addresses the core aspects of creating a reliable and ethical environment for its implementation. This section proposes strategies to establish trust in AI-driven education.

To establish a roadmap for trustworthy AI in education, several measures must be enacted across various dimensions. Figure 2 presents the key steps in building trustworthy AI in education.

4.2 Consideration & Requirements

First, the actor initiating an AI intervention in her or his educational institution, so-called AI champion, needs to identify key considerations & requirements for trustworthy & human acceptable AI over its whole lifecycle. Questions to be addressed include: "do stakeholders understand the AI?", "do stakeholders accept the AI?", "what are the applicable legal regimes for an educational pilot" and "how do stakeholders prefer to get support from/partner with the AI?". The champion will work with the pilot stakeholders in the first instance to identify what they perceive to be their main challenges and provide guidance to respond to those challenges on an ongoing basis to identify the main stakeholders for trustworthy AI and their potentially conflicting requirements and expectations. The analysis will be used to identify priorities for the initiative and

an assessment of the implications for the acceptance of trustworthy AI by different stakeholders, leading to a checklist for individual stakeholders for what to consider when engaging with trustworthy AI. Further, the AI champion will look outward to engage with potential stakeholders not directly involved in the project, such as student parents, but who could be affected by the AI to assess their perceptions its trustworthiness before and after the experience of the project and the guidance generated as part of it. Engagement will be via a combination of techniques, such as anonymous survey, focus group discussion, co-design and ethnographic study. These considerations should then be synthesized into AI trustworthiness requirements targeted at data scientists and technology developers.

Requirements may be categorized under the four main AI application types in education: student supporting, student teaching, teacher supporting, and system supporting [34]. Requirements should be split in functional and non-functional ones. In turn, functional ones may focus on the modes and means of interacting with AI, e.g., through a conversational, graphical or voice-enabled interface, the specific support expected by AI as well as ways of triggering interaction with AI. For example, a user may require that "It would be beneficial in providing real-world examples to certain applications and terms described in the textbook". Finally, requirements should cover the types of educational content the AI should utilize as well as its specific academic goals, e.g., theorem proving. Of equal importance is the elicitation of non-functional requirements, such as system responsiveness, interactivity, confidentiality, emotional connection, to name a few.

4.3 Risk Analysis

Prior to engaging with AI interventions in an educational environment, stakeholders can benefit from a risk assessment of the envisaged AI system in its socio-technical context. If possible, indicators to the risk model may be constructed and drive inference of risks to e.g., fairness, accuracy, transparency, privacy, etc. These may then be used as decision factors elicited by consultation and engagement with key stakeholder groups.

Our analysis in Section 3 revealed that trustworthy AI is education comprises many dimensions, such as validity and reliable, fair and unbiased, etc. Any breach of AI trustworthiness can lead to consequences, however, not all the above dimensions of trustworthiness are equally important across the various applications and pilots. Therefore, without contextual knowledge, and awareness of risks within the identified contexts, risk management is difficult to perform. In the context of these activities, the intended purpose, potentially beneficial uses, context specific regulations and policies, and prospective settings in which the AI system will be deployed need to be understood and documented. The AI champion should also make sure that practices for supporting regular engagement with relevant educational actors and for integrating feedback about positive, negative, and unanticipated impacts.

4.4 Implementation

The development of AI-driven educational technologies demands a deep understanding of both technical and ethical considerations. Improving data preprocessing techniques is critical for enhancing

the quality and reliability of AI training data. Research and implementation of algorithms that prioritize fairness for all students and mitigate biases against specific types or groups of students are essential steps towards building more trustworthy AI educational systems. Also, innovations in methods for enhancing interpretability and transparency of AI models are crucial for ensuring accountability and fostering user trust. Furthermore, laying the foundations for safe use of AI in the classroom requires a holistic approach that integrates technical expertise with ethical principles. Principles of robustness, fairness, and explainability must be embedded into the AI development processes. By providing training and education on ethical AI use, educators and students will explore the ethical complexities of AI. Establishing protocols for addressing security vulnerabilities and minimizing risks associated with AI implementation is crucial for ensuring the safety and integrity of AI.

4.5 Validation & Feedback Loop

Lastly, conducting assessments on the influence of AI and collecting feedback from stakeholders are essential for ensuring the efficacy and integrity of AI implementations in education. Evaluating the impact of AI on educational outcomes, student performance, and teacher effectiveness is crucial for guiding future investments and policy decisions. Additionally, collecting feedback from stakeholders to assess the usability and effectiveness of AI applications is essential for identifying areas for improvement and refinement. Stakeholder feedback provides valuable insights into user experiences, concerns, and suggestions for improvement. By establishing feedback mechanisms, developers and policymakers can iteratively refine AI systems based on real-world usage and stakeholder input, enhancing their usability, effectiveness, and acceptance.

A well-constructed and validated instrument to measure the impact of AI in higher education is reported in [35]. The instrument utilizes methods such as Exploratory Factor Analysis and enables rigorous assessment of the influence of AI on students' learning experiences and academic performance, while curriculum developers can evaluate and improve existing AI-related curricula based on the instrument's feedback. Overall, instrument like this serve as a valuable tool for enhancing AI integration in higher education, optimizing its benefits for learners and ensuring the responsible and effective integration of AI technologies to enhance teaching and learning experiences.

5 Conclusions

In conclusion, the integration of AI into educational systems has the potential to improve teaching and learning experiences. Firstly, the paper has described the benefits of AI in education, from personalized learning pathways to efficient administrative processes. By employing the ALTAI framework, the paper has highlighted key challenges to trustworthiness in AI-driven education. These challenges include concerns regarding data privacy, algorithmic bias, and transparency. Recognizing these obstacles is the first step towards overcoming them. In response to these challenges, the paper has proposed a roadmap for ensuring trust in AI-driven education. By following the proposed roadmap and addressing the identified challenges, educational institutions can promote an environment of trust, transparency, and accountability in AI-driven education.

Acknowledgments

References

[1] Shneiderman, B. (2020). Bridging the gap between ethics and practice: guidelines for reliable, safe, and trustworthy human-centered AI systems. ACM Transactions on Interactive Intelligent Systems (TiiS), 10(4), 1-31.

[2] Floridi, L., Cowls, J., Beltrametti, M., Chatila, R., Chazerand, P., Dignum, V., ... & Vayena, E. (2018). AI4People—an ethical framework for a good AI society: opportunities, risks, principles, and recommendations. Minds and machines, 28, 689-707.

[3] Mentzas, G., Fikardos, M., Lepenioti, K., & Apostolou, D. (2024). Exploring the Landscape of Trustworthy Artificial Intelligence: Status and Challenges. Intelligent Decision Technologies, forthcoming issue.

[4] HLEG-AI (High-Level Expert Group on Artificial Intelligence), "Ethics Guidelines for Trustworthy AI: Requirements of Trustworthy AI," 2019. Accessed on: September 2021. Available: https://ec.europa.eu/futurium/en/ai-alliance-consultation/guidelines/1

[5] European Commission (2022), Ethical guidelines on the use of artificial intelligence (AI) and data in teaching and learning for Educators, Luxembourg: Publications Office of the European Union, 2022.

[6] Yang, S. J., Lin, C. C., Huang, A. Y., Lu, O. H., Hou, C. C., & Ogata, H. (2023). AI and big data in education: Learning patterns identification and intervention leads to performance enhancement. Information and Technology in Education and Learning, 3(1), Inv-p002.

[7] Lu, C., & Cutumisu, M. (2021). Integrating Deep Learning into an Automated Feedback Generation System for Automated Essay Scoring. International Educational Data Mining Society.

[8] Hooda, M., Rana, C., Dahiya, O., Rizwan, A., & Hossain, M. S. (2022). Artificial intelligence for assessment and feedback to enhance student success in higher education. Mathematical Problems in Engineering, 2022, 1-19.

[9] Lee, C. A., Huang, N. F., Tzeng, J. W., & Tsai, P. H. (2023). AI-Based Diagnostic Assessment System: Integrated with Knowledge Map in MOOCs. IEEE Transactions on Learning Technologies.

[10] Nimy, E., Mosia, M., & Chibaya, C. (2023). Identifying At-Risk Students for Early Intervention—A Probabilistic Machine Learning Approach. Applied Sciences, 13(6), 3869.

[11] Biernacka, K., & Pinkwart, N. (2021). Opportunities for adopting open research data in Learning Analytics. In Advancing the Power of Learning Analytics and Big Data in Education (pp. 29-60). IGI Global.

[12] Holmes, W., Persson, J., Chounta, I. A., Wasson, B., & Dimitrova, V. (2022). Artificial intelligence and education: A critical view through the lens of human rights, democracy and the rule of law. Council of Europe.

[13] Smuha, N. A. (2020). Trustworthy artificial intelligence in education: Pitfalls and pathways. Available at SSRN 3742421.

[14] Vincent-Lancrin, S., & Van der Vlies, R. (2020). Trustworthy artificial intelligence (AI) in education: Promises and challenges.

[15] Cross, J. R., Frazier, A. D., Kim, M., & Cross, T. L. (2018). A comparison of perceptions of barriers to academic success among high-ability students from high-and low-income groups: Exposing poverty of a different kind. Gifted Child Quarterly, 62(1), 111-129.

[16] Sukhai, M. A., Mohler, C. E., Doyle, T., Carson, E., Nieder, C., Levy-Pinto, D., ... & Smith, F. (2014). Creating an accessible science laboratory environment for students with disabilities. Council of Ontario Universities, 1-28.

[17] Burgstahler, S. (2012). Making science labs accessible to students with disabilities. DO-IT, University of Washington

[18] Wang, T., & Cheng, E. C. K. (2021). An investigation of barriers to Hong Kong K-12 schools incorporating Artificial Intelligence in education. Computers and Education: Artificial Intelligence, 2, 100031. https://doi.org/10.1016/j.caeai.2021.100031

[19] Cope, B., & Kalantzis, M. (2019). Education 2.0: Artificial intelligence and the end of the test. Beijing International Review of Education, 1, 528–543. https://doi.org/10.1163/25902539-00102009

[20] Vedder, A., & Naudts, L. (2017). Accountability for the use of algorithms in a big data environment. International Review of Law, Computers & Technology, 31(2), 206-224.

[21] Remian, D. (2019). Augmenting education: Ethical considerations for incorporating artificial intelligence in education. ScholarWorks at UMass Boston. University of Massachusetts Boston. https://scholar-works.umb.edu/instruction_capstone/52

[22] Luckin, R., & Holmes, W. (2016). Intelligence unleashed: An argument for AI in education. https://discovery.ucl.ac.uk/id/eprint/1475756/

[23] Muehlenbrock, M. (2006). "Learning Group Formation Based on Learner Profile and Context". International Journal on elearning. 5(1), 19

[24] Yujie, Xue. 2019. 'Camera Above the Classroom'. Sixth Tone. 26 March 2019. https://www.sixthtone.com/news/1003759/camera-above-the-classroom.

[25] Bulger, Monica. 2016. 'Personalized Learning: The Conversations We're Not Having'. Data & Society,July, 29.

[26] Novelli, C., Taddeo, M., & Floridi, L. (2023). Accountability in artificial intelligence: what it is and how it works. AI & SOCIETY, 1-12.

[27] Schwartz, Roy, Jesse Dodge, Noah A. Smith, and Oren Etzioni. 2019. 'Green AI'. ArXiv:1907.10597 [Cs, Stat], August. http://arxiv.org/abs/1907.10597.

[28] Vesnic-Alujevic, L., Nascimento, S., & Polvora, A. (2020). Societal and ethical impacts of artificial intelligence: Critical notes on European policy frameworks. Telecommunications Policy, 44(6), 101961.

[29] Miao, F., Holmes, W., Huang, R., & Zhang, H. (2021). AI and education: A guidance for policymakers. UNESCO Publishing.

[30] Fagan, F., & Levmore, S. (2019). The impact of artificial intelligence on rules, standards, and judicial discretion. S. Cal. L. Rev., 93, 1.

[31] Tong, J. R., & Lee, T. X. (2023). Trustworthy ai that engages humans as partners in teaching and learning. Computer, 56(5), 62-73.

[32] Tabassi, E. (2023). Artificial intelligence risk management framework (ai rmf 1.0).https://tsapps.nist.gov/publication/get_pdf.cfm?pub_id$=$936225

[33] Floridi, L., Holweg, M., Taddeo, M., Amaya, J., Mökander, J., & Wen, Y. (2022). CapAI-A procedure for conducting conformity assessment of AI systems in line with the EU artificial intelligence act. Available at SSRN 4064091.

[34] Chiu, T. K., Moorhouse, B. L., Chai, C. S., & Ismailov, M. (2023). Teacher support and student motivation to learn with Artificial Intelligence (AI) based chatbot. Interactive Learning Environments, 1-17.

[35] Capinding, A. T. (2024). Development and Validation of Instruments for Assessing the Impact of Artificial Intelligence on Students in Higher Education. International Journal of Educational Methodology, 10(issue-2-may-2024), 197-211.