The Academic
International Journal of Multidisciplinary Research

An Online Peer Reviewed / Refereed Journal
Volume 3 | Issue 12 | December 2025
ISSN: 2583-973X (Online)
Website: www.theacademic.in

Artificial Intelligence in Higher Education: Role and Challenges

Dr. Sharwan Kumar

Lecturer: District Institute of Education and Training, Pirouta, Bhojpur, Bihar Education Service (B.E.S.)

DOI : https://doi.org/10.5281/zenodo.18256297

ARTICLE DETAILS

Research Paper

Accepted: 26-12-2025

Published: 10-01-2026

Keywords:

Artificial Intelligence, Higher Education, Teaching–Learning Process, Challenges AI, NEP 2020

ABSTRACT

Artificial Intelligence (AI) has emerged as a transformative force in higher education, reshaping teaching–learning processes, assessment systems, administration, and institutional governance. Education plays a crucial role in national development, particularly in developing countries such as India, where higher education is central to human capital formation and socio-economic mobility. Rapid technological advancements, especially in data analytics, machine learning, and automation, have altered traditional educational practices and introduced new possibilities for efficiency, personalization, and accessibility. This theoretical study examines the concept, role, and challenges of Artificial Intelligence in higher education through an extensive review and synthesis of existing scholarly literature, policy documents, and conceptual frameworks. The study highlights that AI applications—such as adaptive learning systems, intelligent tutoring, automated assessment, and learning analytics—have significant potential to enhance learning outcomes, increase student retention, reduce costs, and support evidence-based decision-making. AI can also assist educators by reducing repetitive tasks and enabling more learner-centered pedagogical approaches. However, the study identifies several challenges that hinder effective AI adoption in higher education institutions, particularly in developing contexts. These include inadequate digital infrastructure, limited financial resources, lack of faculty preparedness, ethical and privacy concerns, data security issues,

and insufficient regulatory frameworks. With reference to India, the study aligns AI integration with the objectives of the National Education Policy (NEP) 2020, which emphasizes technology-enabled, inclusive, and quality-driven higher education. The paper concludes that while AI holds immense promise for transforming higher education, its successful implementation requires systematic planning, institutional readiness, ethical governance, and continuous capacity building. AI should be viewed as a supportive and complementary tool rather than a replacement for human educators, ensuring sustainable and equitable development of higher education systems.

1.0 Introduction

Education is fundamental for achieving full human potential, developing an equitable and just society, and promoting national development. Education is the practice of gaining knowledge and information that are capable of leading one to a positive future. Education has been broadly advocated as a crucial pillar of the human resource improvement of any society across the globe (Al-Shuaibi, 2014).

Education plays a significant role for people residing in developing countries. Higher education centers are playing an important role in a nation's development. People who are highly educated are more likely to get high skilled jobs and remuneration, hence become capable to lift their living standards. Well educated and skilled students also leads to higher growth and improvement for the country as a whole particularly in developing countries. So, in developing nations like India the role of higher education becomes more important.

Earlier education system was characterized where teachers and students physically interacted in the classroom and majority of work was done manually in the higher education institutions. But, major technological developments in the last two decades, mostly because of the internet, have changed education system and their working, and a new concept has evolved during the last few years i.e. "artificial intelligence".

The higher education system is highly dependent on well-educated and skilled staffs which increase its operational cost. Higher education centers have to spend a big budget on hiring and retaining professors and also in the processing of data. Apart from financial burden in the form of wages these institutions have to put effort into new enrollments, learning and daily operations. In higher education institutes lot of

information and efforts are being wasted on repetitive tasks that can be minimized. Hence, adoption of artificial intelligence is helpful in bringing an economic and more responsive approach to the higher education sector.

1.2 Research Questions

- What is Artificial Intelligence, and how can its concept, nature, and key components be understood in the context of higher education?
- What challenges and constraints are faced in the adoption and implementation of Artificial Intelligence in higher education**,** especially in developing countries like India?

1.3 Objectives of the Study

- To examine the role of Artificial Intelligence in higher education.
- To identify the challenges in adopting AI in higher education institutions.
- To review scholarly literature on AI applications in education.
- To suggest future directions for effective AI integration in higher education.

2.0 Concept of Artificial Intelligence

Artificial intelligence is the technological future that happens to make the lives of human beings a lot easier. It is a booming technological domain capable of altering every aspect of our social interactions. In education, AI has been seen to have already begun initiating new teaching and learning solutions that are currently under trial and undergoing restructuring in different contexts (Bostrum, 2017).*"Computers which perform cognitive tasks, usually associated with human minds, particularly learning and problem solving"* is the broad definition of artificial intelligence (Baker et al., 2010). According to Vries et.al. (2023), artificial intelligence is defined as, *"The ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings."*

Artificial Intelligence (AI) is a technology that enables machines and computers to perform tasks that typically require human intelligence. Due to the unique capacity of machine to think and act like people, importance of AI is rising day by day in all fields including education. Recent developments in AI have brought enormous changes in the field of higher education. AI helps students and teachers to make their educational experience wonderful. Advancement in AI opens to new possibilities and challenges for

teaching and learning in higher education. It is rapidly transforming higher education by improving teaching, learning, administration, and research. It has potential to fundamentally change governance and the internal architecture of institutions of higher education.

AI is characterized as the capacity and improvement of a data innovation by different machines to finish the jobs that typically require human knowledge and rational thinking. Despite the fact that AI can make the world a superior spot, AI accompanies its very own issues (Siau, 2018). Thus, the term AI does not refer to a particular technology rather it refers a variety of tools and techniques, including algorithms, machine learning, data mining, neural networks, and natural language processing.

3.0 Role of Artificial Intelligence in Higher Education

Artificial Intelligence in Education is one of the newest areas of educational technology, according to several worldwide studies (Zawacki-Richter et al., 2019). Governments, the education sector, and technology organizations have been investigating the introduction of AI tools and platforms to deliver educational system monitoring that is more effective (with timely, accurate, and informative indicators) and efficient (with less administrative burden) than in the current educational system in order to realize these benefits (Rosak Szyrocka, 2024).

For instance, Bates (2018) have listed the following goals for AI in higher education:

- Increase outcomes
- Increase access
- Increase retention
- Lower cost
- Decrease time to completion.

Though, Huang (2018) emphasizes AI's role in innovating education, noting its ability to transform learning interactions from machine-focused to knowledge-centered approaches based on learner needs. The findings of Kuleto et al. (2021) demonstrate the significance of AI in improving learning outcomes, particularly in enhancing students' skills, promoting collaborative learning, and providing a more accessible research environment.

AI has the potential to transform higher education by enhancing teaching and learning, improving assessment and feedback, increasing access and retention, reducing costs and time, and supporting administration and management (Abdous, 2023; UNESCO, 2021).

Thus, numerous research works have demonstrated the importance of artificial intelligence for teachers and students in higher education. Researchers have found application of AI encourages more flexible learning solutions for students without any limitation. With the help of increased flexibility and speed due to use of artificial intelligence universities around the world are enrolling increased number of students.

AI is used in education system in grading, in this process teachers can mechanize grading of students for certain fixed set of questions. AI can also be used in adaptive and individualized learning to fulfill students' requirements. AI assists the teachers to access the understanding capacity of the students on their lectures and empower them to give the appropriate clues for students.

It works as a teacher for the students and makes them learn concepts easily. Artificial intelligence driven projects provide supportive input for the both students and teachers. AI frameworks in schools have changed the manner in which students find and cooperate with coordinated innovation. Students can learn by the experimentation strategy without fear as AI helps in their learning and their improvement.

AI may even supplement educators in certain situations. It has turned into a learning buddy the helps students in their learning procedure (Sharma, C., 2021). Artificial Intelligence (AI) creates an encouraging environment, especially, can provide a favorable context for students learning characteristics and process.

Artificial intelligence consists of all forms of electronically reinforced learning, processing and teaching. The easy and flexible structure of these AI influenced environments empowers learners to accommodate their personal needs in their own time learning. Thus, we can say that AI is a well-designed tool that offers a flexible arrangement, collaboration opportunities, and options and control over learning process that can provide learners and teachers with the opportunity to pursue learning process effectively.

Teachers can create a learning environment using AI that permits the students to develop a better understanding of content and build associations with instructors and students. Entire globe has completely digitalized. Education has definitely been influenced by the digital world. The fast paced technology provides individuals in the area to training and learning with unlimited possibilities. With the global interest in computers, artificial intelligence has been focused in learning environment.

Computers have potential advantages to both the instructors and the students. With the arrival of the computer, AI is playing an important role in the higher education institutes. Plenty of programs have been created for various fields or professional classes. The conventional teaching and learning methods

usually lack efficient methods of explaining an intuitional and clear material, while AI can make up through the use of new software and hardware methods. From the viewpoint of AI program, there is more scope in teaching in the classroom compared to other mere learning methods. Thus, the emphasis is given on adopting AI in the classroom as well as outside classroom.

4.0 Review of Related Literature

Over the last decade, rapid digitalization through computers, the internet, and data-driven technologies has significantly influenced classroom instruction, leading to the emergence and expansion of Artificial Intelligence (AI) in education. This technological shift has reshaped pedagogical practices, instructional delivery, assessment mechanisms, and institutional management, particularly in higher education.

4.1 AI and Transformation of Teaching–Learning Processes: Several studies indicate that AI is transforming the nature of teaching and learning by enabling personalized learning and automated assessment. Lin, Huang, and Lu (2023) emphasize that AI-driven systems facilitate individualized learning pathways and continuous feedback, thereby reforming traditional instructional practices and redefining the division of labor in education. Similarly, Kamruzzaman et al. (2023) report that AI tools positively impact personalized learning experiences by adapting content to learners' abilities and learning pace.

AI-powered tutoring systems and adaptive learning environments further enhance learner engagement and provide real-time academic support. Gligorea et al. (2023) highlight that adaptive learning systems encourage individualized learning experiences, while AI-based tutoring systems offer instant assistance and feedback, promoting deeper conceptual understanding (Lin et al., 2023).

4.2 AI in Virtual Learning and Emergency Education Contexts: The role of AI in ensuring continuity of education during crises has gained scholarly attention. During emergency situations such as conflicts and pandemics, AI-based tools have supported remote and flexible learning. Danylchenko-Cherniak (2023) illustrates how AI helped maintain a "normal" educational process amid the Ukrainian conflict. Similarly, Pantelimon et al. (2021) observe that AI-enabled educational applications and virtual classrooms played a crucial role in ensuring accessibility during the COVID-19 pandemic. AI has also enabled the deployment of remote learning systems for students affected by natural disasters and emergencies. Bakhov et al. (2021) emphasize that AI-supported distance education systems provide inclusive access to learning resources, regardless of geographical and situational constraints.

4.3 AI Applications and Educational Technologies: With advancements in computing and information processing, AI has been widely applied in educational practices. Chen et al. (2020) identify various AI applications in education, including intelligent tutoring systems, teaching robots, adaptive learning systems, learning analytics dashboards, and human–computer interaction tools. These applications support instructional design, enhance learner engagement, and enable data-driven decision-making in higher education institutions. Rahmani et al. (2021) further argue that AI strengthens teaching methodologies by optimizing teaching resources and facilitating evidence-based academic planning through learning analytics.

4.4 AI, Innovation, and New Educational Paradigms: AI has been recognized as a powerful catalyst for innovation in educational research and instructional design. Holmes et al. (2022) and Hwang et al. (2020) suggest that AI enables the development of new educational paradigms that are not feasible in conventional settings. These include intelligent learning environments, predictive learning analytics, and context-aware instructional systems. However, AI has also introduced complexities, such as increased system sophistication and evolving teacher roles. Ouyang and Jiao (2021), along with Holmes et al. (2018), note that while AI opens new opportunities for individualized learning, it simultaneously raises challenges related to instructional design, teacher autonomy, and system integration.

4.5 Conceptual Foundations and Types of Artificial Intelligence: From a conceptual perspective, modern AI does not aim to create "super-intelligent" machines but focuses on developing systems capable of learning, adapting, predicting outcomes, and performing tasks autonomously (Alpaydin, 2021; Mackenzie, 2017). Voss (2017) categorizes AI into Weak AI (Artificial Narrow Intelligence), designed for specific tasks, and Strong AI (Artificial General Intelligence), which aims to replicate broad human cognitive abilities. Understanding these distinctions is essential for analyzing the realistic applications of AI in higher education, where most current implementations fall under Weak AI.

4.6 AI, Workforce Transformation, and Curriculum Development: AI's influence extends beyond pedagogy to workforce transformation and skill development. Siau (2017, 2018) argues that AI-driven automation will significantly alter future job markets, requiring new skill sets and competencies. Consequently, higher education institutions must adapt curricula to prepare students for AI-driven economies. Aoun (2017) emphasizes the importance of integrating AI education into higher education curricula to ensure that graduates can contribute responsibly to AI development while addressing ethical, social, and economic concerns. Du Boulay (2016) and Loeckx (2016) also highlight AI's potential to reduce teachers' workload while providing engaging and adaptive learning opportunities for students.

5.0 Research Gap

A review of existing literature indicates that Artificial Intelligence (AI) has been widely examined for its potential to enhance teaching–learning processes, personalized learning, assessment, and administrative efficiency in higher education. Most studies highlight the benefits and applications of AI, particularly in technologically advanced and developed countries. However, **limited theoretical attention has been given to the context of developing countries such as India**, where higher education institutions face challenges related to infrastructure, funding, digital readiness, and faculty preparedness. Moreover, existing research often addresses AI applications and challenges in a fragmented manner, without offering an integrated understanding of conceptual foundations, institutional constraints, and pedagogical implications. The changing role of teachers, ethical concerns, data privacy issues, and long-term sustainability of AI adoption remain underexplored. Additionally, there is a lack of comprehensive synthesis linking the role, challenges, and future directions of AI in higher education. Therefore, a clear research gap exists for a holistic theoretical study that critically examines the role and challenges of Artificial Intelligence in higher education, with special reference to developing countries like India.

5.1 Justification of the Present Study

In light of these gaps, the present study attempts to **theoretically examine the concept, role, and challenges of Artificial Intelligence in higher education** by synthesizing existing literature. The study aims to provide a **holistic understanding** of AI integration, with particular emphasis on the challenges faced by higher education institutions in developing countries like India, and to suggest future directions for effective and responsible adoption of AI in higher education.

6.0 Challenges for Artificial Intelligence in Education

There are numerous benefits of artificial intelligence for teachers, students and higher education institutions, the possibilities of AI are also impressive. Despite numerous advantages there are few challenges before higher education institutions at the time of adopting artificial intelligence in their universities.

Developed nations of the world have already implemented the process of artificial intelligence successfully. However, developing nations including India are still at a preliminary stage compared to developed countries in artificial intelligence implementation. Poor infrastructure and information access, lack of support from institutes, insufficient necessary resources, poor technological skills, these are

various obstacles before developing countries eager to incorporate artificial intelligence as a tool in higher education.

The implementation of artificial intelligence in teaching has also proven relatively expensive but when compared with the other manual work related costs it comes out as economical. Though, use of artificial intelligence in the long run among college students is far more cost effective compared to education being conducted in a more traditional way and tasks done manually.

Major challenges for artificial intelligence in Education as proposed by Woolf, et al., (2013) incorporates virtual coaches for each student in which inevitable help that coordinates user displaying, social re-enactment and information portrayal, helps students with self-heading, self-evaluation, collaboration and then some, unite the tremendous measures of information about individual learning, social settings, learning settings and individual interests, increment the inter connectedness and openness of classrooms worldwide and taking learning outside of the study hall and into the student life outside of school. The job that Artificial intelligence plays in advanced digital world is wonderful and it is relied upon to propel learning knowledge increasingly more sooner in the near future. (Sharma C, 2021.)

Authorization and economic support are a constraint for the updated academic achievement and instructional support given by AI. Privacy regulations are also a big constraint as it always requires to be updated. Interfacing with students is another constraint.

Artificial intelligence assumes few current job duties, like evaluating and responding to students inquiries, directors and employees will most likely move their concentration to answering complex issues and interfacing with students on more profound dimensions. AI can open up tremendous new conceivable outcomes for advanced higher education, and establishments that set aside the effort to incorporate it well will appreciate the advantages it brings to students, educators, and heads of the institutes.

7.0 Policy Implications

7.1 National Education Policy (NEP 2020) and Artificial Intelligence: The National Education Policy (NEP) 2020 of India strongly emphasizes the integration of technology to improve access, equity, and quality in education, and Artificial Intelligence (AI) is identified as a key enabler in achieving these goals. NEP 2020 encourages the use of emerging technologies such as AI, machine learning, and data analytics to support personalized learning, digital infrastructure development, and innovative pedagogical

practices in higher education. The policy advocates multidisciplinary education, flexible curricula, and technology-enabled assessment systems, all of which can be strengthened through AI-driven solutions. However, effective alignment between AI initiatives and NEP 2020 requires systematic planning, capacity building, and targeted investment to ensure that AI adoption contributes meaningfully to inclusive and learner-centered higher education.

Institutional Governance

The integration of AI in higher education has important implications for institutional governance. Universities and colleges need to develop clear institutional policies related to AI adoption, including guidelines for ethical use, data management, transparency, and accountability. Institutional leadership must play a proactive role in fostering digital readiness by investing in infrastructure, faculty training, and technical support systems. Governance frameworks should also promote collaboration between academic departments, technology providers, and policymakers to ensure that AI tools align with educational objectives rather than merely administrative efficiency. Strong institutional governance is essential to balance innovation with academic values, teacher autonomy, and student welfare.

7.2 Regulatory Preparedness in India: Regulatory preparedness remains a critical concern in the Indian higher education system. While AI adoption is increasing, comprehensive regulatory frameworks addressing data privacy, algorithmic bias, intellectual property, and academic integrity are still evolving. Regulatory bodies such as the University Grants Commission (UGC) and All India Council for Technical Education (AICTE) need to formulate clear guidelines for responsible AI use in teaching, learning, assessment, and administration. Ensuring regulatory clarity will help institutions adopt AI confidently while safeguarding ethical standards and protecting stakeholder interests. A well-defined regulatory environment is crucial for the sustainable and equitable integration of Artificial Intelligence in Indian higher education.

8.0 Limitations of the Study

The present study is theoretical in nature and is primarily based on secondary sources such as journal articles, policy documents, and reports. As a result, it does not include empirical data or field-based evidence from higher education institutions, which may limit the generalizability of its findings. The study mainly synthesizes existing literature and may reflect biases present in prior research, particularly those originating from developed countries (Zawacki-Richter et al., 2019). Additionally, rapid

advancements in Artificial Intelligence mean that policies, technologies, and applications discussed may evolve quickly, potentially affecting the relevance of some findings (UNESCO, 2021). The study also does not examine discipline-specific AI applications in detail, which could offer more nuanced insights into sector-wise implementation challenges.

8.1 Future Research Directions

Future research on Artificial Intelligence (AI) in higher education should move beyond theoretical discussions and focus on empirical, context-specific investigations, particularly in developing countries like India. Longitudinal and mixed-method studies are needed to examine the long-term impact of AI on student learning outcomes, equity, employability, and institutional effectiveness. Further research should explore discipline-specific applications of AI to understand how its role and effectiveness vary across fields such as humanities, social sciences, and professional education. The changing role of teachers in AI-supported learning environments also warrants in-depth investigation, especially in terms of professional identity, pedagogical autonomy, and capacity building. Additionally, future studies should critically examine ethical issues related to data privacy, algorithmic bias, transparency, and academic integrity in AI-driven systems. Research focusing on governance models and regulatory frameworks can provide insights into responsible and sustainable AI adoption. Finally, comparative studies between developed and developing nations may help identify best practices and scalable models for inclusive and learner-centered integration of AI in higher education.

9.0 CONCLUSION

This theoretical paper has examined the concept, role, and challenges of Artificial Intelligence (AI) in higher education with particular reference to developing countries such as India. Drawing upon an extensive review of scholarly literature, policy documents, and conceptual frameworks, the study highlights that AI has emerged as a powerful technological force capable of transforming teaching–learning processes, assessment practices, administrative efficiency, and institutional governance. AI-driven tools such as adaptive learning systems, intelligent tutoring, learning analytics, and automated assessment offer significant potential to enhance access, personalization, flexibility, and quality in higher education.

At the same time, the study reveals that the adoption of AI in higher education is accompanied by substantial challenges, especially in developing contexts. Issues related to inadequate infrastructure,

limited digital readiness, insufficient funding, lack of faculty training, ethical concerns, data privacy, and regulatory preparedness continue to constrain effective implementation. The paper also underscores the evolving role of teachers and institutions in an AI-supported educational ecosystem, emphasizing the need to balance technological innovation with academic values, human judgment, and inclusivity.

Aligned with the National Education Policy (NEP) 2020, the study concludes that successful and sustainable integration of AI in higher education requires systematic planning, strong institutional governance, supportive regulatory frameworks, and continuous capacity building. Overall, AI should be viewed not as a replacement for educators, but as a complementary tool that can strengthen higher education systems and prepare learners to meet the demands of an AI-driven future.

REFERENCES

- Abdous M (2023) How AI Is Shaping the Future of Higher Ed. Inside Higher Ed | Higher Education News, Events and Jobs.
- All India Council for Technical Education. (2022). *AICTE policy on use of artificial intelligence and emerging technologies in technical education*. AICTE, New Delhi.
- Alpaydin, E. (2021). Machine learning, revised and updated edition. New York: MIT Press.
- Al-Shuaibi, A. (2014). The Importance of Education. https://www.researchgate.net /publication/260075970
- Aoun, J. E. (2017). *Robot-proof: Higher education in the age of artificial intelligence*. MIT Press.
- Baker, R.S., D'Mello, S.K., Rodrigo, M.T., Graesser, A.C. (2010). Better to be frustrated than bored: The incidence, persistence, and impact of learners' cognitive–affective states during interactions with three different computer-based learning environments. International Journal of Human-Computer Studies, vol. 68, no. 4, pp. 223-241.
- Bakhov, I., Opolska, N., Bogus, M., Anishchenko, V., & Biryukova, Y. (2021). Emergency remote teaching in higher education: Challenges and opportunities. *Education Sciences, 11*(7), 1–15.

- Bates, L., Hayes, H. (2017). Using the Student Lifecycle Approach to Enhance Employability: An Example from Criminology and Criminal Justice. Asia-Pacific Journal of Cooperative Education, vol. 18, no. 2, pp. 141-151.
- Bates, T. (2018). Another perspective on AI in higher education Tony Bates. Www.tonybates.ca. https://www.tonybates.ca/2018/12/02/another-perspective-on-ai-in-higher-education/
- Bostrom, N. (2017). Superintelligence: Paths, dangers, strategies. Oxford University Press, Cop.
- Chan, C.K.Y. (2023). A comprehensive AI policy education framework for university teaching and learning. International Journal of Educational Technology in Higher Education, vol. 20, no. 1, pp. 1-25.
- Chen, L., Chen, P., & Lin, Z. (2020). Artificial intelligence in education: A review. *IEEE Access, 8*, 75264–75278.
- Chmyr, V., Bhinder, N. (2023). AI in the Higher Military Institutions: Challenges and Perspectives for Military Engineering Training. Rupkatha Journal on Interdisciplinary Studies in Humanities, vol. 15, no. 4.
- Chu HC, Hwang GH, Tu YF, Yang KH (2022) Roles and research trends of artificial intelligence in higher education: A systematic review of the top 50 most-cited articles. Australasian Journal of Educational Technology 38(3):22–42
- Dai C-P, Ke F (2022) Educational applications of artificial intelligence in simulation-based learning: A systematic mapping review. Computers and Education: Artificial Intelligence 3:100087.
- Danylchenko-Cherniak, O. (2023). Artificial intelligence in education during armed conflict: Ensuring learning continuity. *Education and Information Technologies, 28*(4), 5123–5140.
- Du Boulay, B. (2016). Artificial Intelligence as an Effective Classroom Assistant. IEEE Intelligent Systems, vol. 31, no. 6, pp. 76-81.
- Gligorea, I., Cioca, M., Oancea, R., Gorski, A.-T., Gorski, H., Tudorache, P. (2023). Adaptive Learning Using Artificial Intelligence in e-Learning: A Literature Review. Education Sciences, vol. 13, no. 12, p. 1216.
- Government of India. (2020). *National Education Policy 2020*. Ministry of Education. https://www.education.gov.in

- Holmes, W., Anastopoulou, S., Schaumburg, H., Mavrikis, M. (2018). Technologyenhanced Personalised Learning: Untangling the Evidence. Stuttgart: Robert Bosch Stiftung GmbH.
- Holmes, W., Bialik, M., & Fadel, C. (2018). *Artificial intelligence in education: Promises and implications for teaching and learning*. Center for Curriculum Redesign.
- Holmes, W., Persson, J., Chounta, I., & Dimitrova, V. (2022). AI-supported education: A critical review. *Computers and Education: Artificial Intelligence, 3*, 100065.
- Huang S-P (2018) Effects of Using Artificial Intelligence Teaching System for Environmental Education on Environmental Knowledge and Attitude. Eurasia Journal of Mathematics, Science and Technology Education 14(7):3277–3284.
- Hwang, G. J., Xie, H., Wah, B. W., & Gašević, D. (2020). Vision, challenges, and future directions of AI in education. *IEEE Transactions on Learning Technologies, 13*(2), 1–10.
- Kamalov, F., Santandreu Calonge, D., Gurrib, I. (2023). New Era of Artificial Intelligence in Education: Towards a Sustainable Multifaceted Revolution. Sustainability, vol. 15, no. 16, p. 12451.
- Kamruzzaman, M.M., Alanazi, S., Alruwaili, M., Alshammari, N., Elaiwat, S., AbuZanona, M., Innab, N., Mohammad Elzaghmouri, B., Ahmed Alanazi, B. (2023). AI- and IoT-Assisted Sustainable Education Systems during Pandemics, such as COVID-19, for Smart Cities. Sustainability, vol. 15, no. 10, p. 8354
- Kuleto V, Ilić M, Dumangiu M, Ranković M, Martins OMD, Păun D, Mihoreanu L (2021) Exploring Opportunities and Challenges of Artificial Intelligence and Machine Learning in Higher Education Institutions. Sustainability 13(18):10424
- Lin, C.-C., Huang, A.Y.Q., Lu, O.H.T. (2023). Artificial intelligence in intelligent tutoring systems toward sustainable education: a systematic review. Smart Learning Environments, vol. 10, no. 1, pp. 1-22.
- Loeckx, J. (2016). Blurring boundaries in education: AI and the changing role of teachers. *International Journal of Educational Technology in Higher Education, 13*(1), 1–11.
- Mackenzie, A. (2017). Machine learners. Archaeology of a data practice. Cambridge (Estados Unidos), London: The MIT Press.

- OECD. (2021). *Artificial intelligence, ethics and higher education policy*. OECD Publishing. https://doi.org/10.1787/4cfd4b89-en
- Ouyang, F., & Jiao, P. (2021). Artificial intelligence in education: The three paradigms. *Computers and Education: Artificial Intelligence, 2*, 100020.
- Pantelimon, F. V., Georgescu, T. M., & Posedaru, B. S. (2021). The impact of AI on education during COVID-19. *Sustainability, 13*(8), 1–17.
- Rahmani, A.M., Azhir, E., Ali, S., Mohammadi, M., Ahmed, O.H., Yassin Ghafour, M., Hasan Ahmed, S., Hosseinzadeh, M. (2021). Artificial intelligence approaches and mechanisms for big data analytics: a systematic study. PeerJ Computer Science, vol. 7, e488.
- Rainie, L., Anderson, J. (2017), The Future of Jobs and Jobs Training, Pew Research Center, Retrieve〕from http://www.pewinternet.org/2017/05/03/the-future-of-jobs-and-jobs-training/
- Ruiz-Rojas, L.I., Acosta-Vargas, P., De-Moreta-Llovet, J., Gonzalez-Rodriguez, M. (2023). Empowering Education with Generative Artificial Intelligence Tools: Approach with an Instructional Design Matrix. Sustainability, vol. 15, no. 15, p. 11524.
- Rosak-Szyrocka, J. (2024). *Innovation in the University 4.0 system based on smart technologies*. Chapman & Hall / Routledge.
- Sharma, C. (2021). "Artificial Intelligence in Education", A New technology in Education that bring the new experience in the developing world, https://www.academia.edu/27719718/Artificial_Intelligence_in_Education.pdf
- Siau K. (2018) Education in the Age of Artificial Intelligence: How will Technology Shape Learning? The Global Analyst, Vol. 7, No. 3, pp. 22-24.
- Siau, K. (2017) Impact of Artificial Intelligence, Robotics, and Automation on Higher Education. Americas Conference on Information Systems (AMCIS 2017), Boston, MA, August 10-12.
- Siau, K. (2018). Artificial intelligence, automation, and work. *Business Horizons, 61*(6), 1–9.
- Susan, N. A.and Ventsislav, I. (2022). Artificial Intelligence in Higher Education: Challenges and Opportunities. Border Crossing, January - June 2022 Volume: 12, No: 1, pp. 1 – 15
- UNESCO (2021) Artificial Intelligence and Education. Guidance for Policy-makers. The United Nations Educational, Scientific and Cultural Organization, 1-50.

- University Grants Commission. (2023). *Guidelines on adoption of emerging technologies in higher education*. UGC, New Delhi.

- Voss, P. (2017), From Narrow to General AI, Institution Machine, Retrieve from https://medium.com/intuitionmachine/from-narrow-to-general-ai-e21b568155b9
- Vries, A. de, Bliznyuk, N., Pinedo, P. (2023). Invited Review: Examples and opportunities for artificial intelligence (AI) in dairy farms, 2590-2865, vol. 39, no. 1, pp. 14-22.
- Wolniak, R. (2023). Industry 5.0 – characteristic, main principles, advantages and disadvantages. Scientific Papers of Silesian University of Technology. Organization and Management Series, no. 170, pp. 663-678.
- Woolf, B. P., Lane, H. C., Chaudhri, V. K., & Kolodner, J. L. (2013). AI grand challenges for education. AI magazine, 34(4), 66.

- Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education. *International Journal of Educational Technology in Higher Education, 16*(1), 1–27. https://doi.org/10.1186/s41239-019-0171-0