Jurnal Vokasi Informatika (JAVIT), Vol. 5, No. 1, pp. 1-14, February 2025
e-ISSN: 2775 - 6807

Artificial Intelligence in Education: Opportunities and Challenges in the Transition from Industry 4.0 to Society 5.0

Indra Pratama Putra[1*], Muhammad Adri[1] and Dedy Irfan[1]

[1] Department of Electronics Engineering, Faculty of Engineering, Universitas Negeri Padang, Padang, **Indonesia**

*Corresponding Author Email: ricardoindr4@gmail.com
Received October 2, 2024; Revised December 25, 2024; Accepted January 4, 2025.

DOI: https://doi.org/10.24036/javit.v5i1.257

Abstract: The integration of Artificial Intelligence (AI) into education has become increasingly relevant in the era of Industry 4.0 and the transition toward Society 5.0. This study aims to provide a bibliometric analysis of research trends, thematic clusters, and emerging keywords related to AI in education between 2018 and 2025. Using the Publish or Perish software and data from Google Scholar, 200 articles were selected based on relevance and citation metrics. Keyword co-occurrence analysis and visual mapping were conducted using VOSviewer to identify dominant research themes. The results reveal a growing body of literature focused on AI applications in education, with key topics including adaptive learning, machine learning, digital transformation, and human-centered innovation. However, critical gaps remain, particularly in research addressing cultural context, teacher readiness, digital equity, and the long-term impact of AI-driven tools. This study highlights the need for inclusive, ethical, and context-aware approaches to AI in education, offering insights and recommendations for future research aligned with the human-centric values of Society 5.0.

Keywords: Artificial Intelligence; Education; Industry 4.0; Society 5.0; Bibliometric Analysis; VOSviewer; Adaptive Learning; Digital Transformation.

1. Introduction

The rapid advancement of digital technologies has fundamentally transformed various sectors, including education [1]–[3]. Among these technological innovations, Artificial Intelligence (AI) has emerged as one of the most impactful tools in the 21st century [4]–[6]. AI systems are capable of simulating human cognitive functions such as reasoning, problem-solving, and decision-making [7]–[9]. These capabilities are increasingly being integrated into educational environments through applications such as intelligent tutoring systems, adaptive learning platforms, automated assessments, and learning analytics [10]–[12].

Within the framework of the Fourth Industrial Revolution (Industry 4.0), AI plays a central role in redefining how learning is designed, delivered, and evaluated [13], [14]. The integration of AI in education under Industry 4.0 facilitates personalized learning experiences, enhances learner engagement, and optimizes teaching strategies based on real-time data analysis [15], [16]. In Indonesia, efforts have been made to align national education systems with digital transformation agendas by incorporating AI-driven approaches into curriculum development and online learning platforms. However, disparities in infrastructure, teacher readiness, and digital literacy remain significant challenges that hinder the effective implementation of AI technologies in diverse educational contexts [17], [18].

As the global paradigm shifts toward Society 5.0—a vision promoted by Japan that emphasizes the integration of advanced technologies with human-centered values—AI is expected to serve not only as a tool for efficiency but also as a catalyst for ethical and inclusive learning [6], [19]. Unlike Industry 4.0, which focuses primarily on automation and digitalization, Society 5.0 places a stronger emphasis on human well-being, social responsibility, and the cultivation of soft skills such as collaboration, empathy, and ethical reasoning. Educational systems under Society 5.0 must therefore evolve to embrace a holistic approach that integrates technological competencies with moral and civic dimensions [6], [20], [21].

Despite growing academic interest in the application of AI in education, existing research often remains fragmented—focusing either on the technological benefits of Industry 4.0 or the humanistic goals of Society 5.0. Furthermore, many studies analyze isolated aspects of AI use in classrooms without systematically exploring the broader transition between these two paradigms. Consequently, there is a pressing need for a comprehensive mapping of scholarly discourse that identifies emerging trends, key contributors, conceptual clusters, and thematic shifts in this domain [3], [22].

This study aims to fill that gap through a bibliometric analysis of peer-reviewed literature on AI in education, specifically within the contexts of Industry 4.0 and Society 5.0. Utilizing tools such as VOSviewer, this research visualizes the intellectual structure and evolution of the field, highlighting key topics, co-authorship networks, and keyword co-occurrences. By doing so, the study seeks to provide educators, researchers, and policymakers with insights into the development of future-ready and ethically grounded educational ecosystems powered by AI.

2. Research Methods

This study adopts a Systematic Literature Review (SLR) methodology integrated with bibliometric analysis techniques to examine the scholarly landscape surrounding the application of Artificial Intelligence (AI) in

education, particularly within the paradigms of Industry 4.0 and Society 5.0. The combination of SLR and bibliometric analysis enables both qualitative synthesis and quantitative mapping of existing academic publications, thereby uncovering prevailing trends, conceptual structures, and potential research gaps [23].

2.1 Data Source and Collection Strategy

The bibliographic data used in this study were retrieved using the Publish or Perish (PoP) software, which utilizes Google Scholar as its primary indexing engine. A comprehensive search was conducted using the following query string: "Artificial intelligence in education" AND ("industry 4.0" OR "society 5.0").

The inclusion criteria were limited to peer-reviewed articles published between 2018 and 2025, written in English, and containing relevant keywords in their titles, abstracts, or keyword sections. The search yielded 200 articles which were initially selected based on citation relevance, publication type, and thematic alignment with the research objective.

The metadata of the selected articles, including titles, abstracts, keywords, authors, publication years, and citation counts, were exported in .RIS and .CSV formats to ensure compatibility with bibliometric analysis tools such as VOSviewer.

2.2 Data Cleaning and Preprocessing

Prior to analysis, the dataset underwent a rigorous data cleaning process using Microsoft Excel. Duplicate entries, non-scholarly sources, and articles lacking thematic relevance were excluded. A total of 185 articles remained after the cleaning phase. Furthermore, keyword normalization was conducted to consolidate synonymous terms and standardize variations in terminology (e.g., “AI”, “artificial intelligence”; “Industry 4.0”, “IR 4.0”).

This preprocessing step was essential to improve the accuracy of keyword co-occurrence analysis, allowing for more robust cluster generation and thematic interpretation in subsequent visualizations.

2.3 Bibliometric Analysis and Visualization

Bibliometric analysis was carried out using VOSviewer, a widely used tool for constructing and visualizing bibliometric networks. In this study, a co-occurrence analysis of author keywords was performed to identify frequently associated terms and to reveal underlying thematic clusters.

The minimum threshold for keyword occurrence was set to 5, resulting in a set of high-frequency terms that reflect the core topics within the dataset. VOSviewer generated a network visualization in which keywords are represented as nodes, while the strength of their co-occurrence is indicated by the proximity and thickness of the connecting lines. Each cluster is distinguished by a different color, signifying distinct thematic areas of research.

The visualization not only aids in identifying dominant research topics but also illustrates the interconnections between educational technologies, policy directions, and pedagogical frameworks associated with AI in the context of Industry 4.0 and Society 5.0. The results of this analysis are presented in detail in the subsequent Results and Discussion section.

3. Results and discussion

3.1 Publication Trends by Year

To understand the development of scholarly interest in Artificial Intelligence (AI) within the context of education, an analysis of publication trends from 2018 to 2025 was conducted. Table 1 summarizes the number of relevant articles published per year.

Table 1. Number of Articles by Year of Publication

Year	Number of Articles
2018	12
2019	18
2020	26
2021	43
2022	56
2023	33
2024	9
2025	3

The data reveals a steady increase in publication activity from 2018 to 2022, peaking in 2022 with 56 articles. This upward trend reflects the growing attention to AI applications in educational environments, coinciding with global transitions toward digitalization and the institutionalization of Education 4.0 strategies. The subsequent decline in 2024 and 2025 may reflect data collection lags or delayed indexing of newer articles rather than a true decrease in interest. These findings align with bibliometric patterns observed in technology-related educational domains [24], [25].

3.2 Most Frequently Occurruing Keywords

To understand the core focus areas of research, keyword analysis was conducted on the 200 collected articles. Keywords reflect the central themes emphasized by authors and their frequency indicates which topics dominate the scholarly conversation.

Table 2. Most Frequently Occurruing Keywords

Keyword	Frequency
Artificial Intelligence	178
Education	155
Industry 4.0	121
Society 5.0	92
Learning	81
Machine Learning	65
Technology	53
Students	48
Teaching	41
Digital Transformation	39

The high frequency of the keywords "Artificial Intelligence," "Education," and "Industry 4.0" underscores their centrality in the research landscape. The presence of "Society 5.0" and "Digital Transformation" indicates a shift from purely technical discussions toward more human-centric and policy-oriented analyses. This reflects the growing interest in leveraging AI not just for instructional automation, but also for ethical, inclusive, and sustainable education systems [26], [27].

3.3 Thematic Clusters of Research

To identify underlying thematic domains, co-occurrence analysis using VOSviewer was conducted. The algorithm grouped keywords into several distinct clusters, each representing a unique research focus.

Table 3. Thematic Clusters Based on Co-occurrence Analysis

Cluster (Color)	Dominant Theme
1 (Green)	AI and Society 5.0
2 (Blue)	Industry 4.0 and Education
3 (Purple)	Humanistic and Learning Transformation
4 (Red)	Generative AI and Chatbots
5 (Orange)	Machine Learning and Data Science
6 (Yellow)	Sustainable Education and Indonesian Context

Cluster (Color)	Dominant Theme
7 (Brown)	Adaptive Systems and Smart Learning

These clusters demonstrate the diversity of AI research in education, ranging from technical aspects such as generative AI to broader sociocultural themes such as educational ethics and regional adaptation. The green cluster, for instance, reflects the shift toward Society 5.0, where human values and well-being are prioritized alongside technological innovation. Meanwhile, the yellow cluster represents localized themes in Southeast Asian contexts, suggesting increased regional engagement in AI-driven educational reform [28].

3.4 Keyword Co-occurrence Visualization

Figure 1 illustrates the network of co-occurring keywords generated by VOSviewer. Each node represents a keyword, and its size correlates with frequency, while proximity and color indicate thematic clustering.

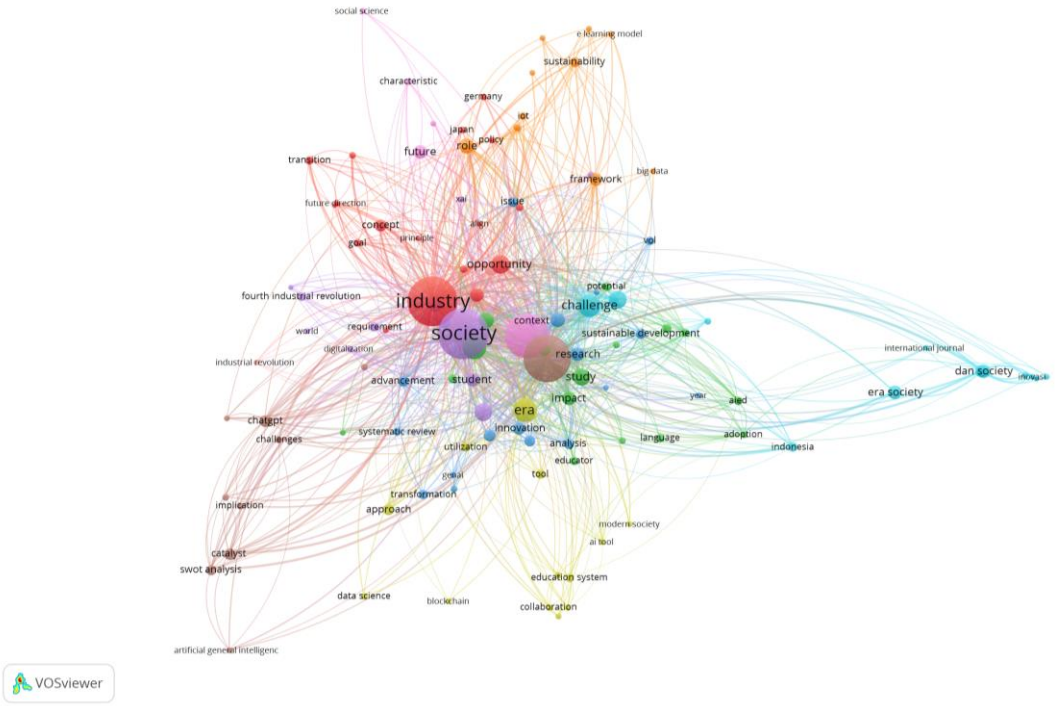

Figure 1. Diagram of Research Results

This visualization highlights the interconnections among key terms forming meaningful thematic clusters. Each cluster represents a dominant focus area, emphasizing that AI in education intersects with broader issues such as Society 5.0, personalization, digital transformation, and ethical considerations. Understanding this structure provides valuable insights into emerging research trends and encourages cross-disciplinary collaboration.

In summary, the bibliometric analysis provides a comprehensive overview of the dynamics of AI research in education, especially in the transition from Industry 4.0 to Society 5.0. The mapping of keywords and thematic clusters shows that the research extends beyond technological applications to include human-centered educational transformation. The presented visualizations and tables support the conclusion that the topic continues to develop rapidly and holds significant potential for future academic inquiry.

3.5 Implications and Research Gaps

The findings of this study highlight that research on Artificial Intelligence (AI) in education is currently situated at a critical inflection point, marked by a shift from purely technological innovation to more human-centric and ethically grounded approaches. Although notable progress has been made in establishing technical architectures—such as intelligent tutoring systems, learning analytics, and AI-based assessment tools—several important gaps remain underexplored. Notably, themes related to cultural adaptation, digital equity, and teacher readiness appeared with low frequency in the co-occurrence analysis, indicating limited scholarly engagement with issues that are essential for successful implementation in diverse educational contexts. This is particularly concerning in developing and under-resourced regions, where educational ecosystems often face infrastructural and socio-economic constraints.

Moreover, there remains a lack of robust empirical studies that assess the long-term effects of AI-integrated learning environments on student achievement, motivation, and critical thinking. Much of the existing literature focuses on theoretical models or pilot implementations, with relatively few contributions offering longitudinal data or cross-cultural comparisons. Another key area requiring further attention is the role of teachers in AI-mediated classrooms. While AI can provide personalized feedback and automate instructional delivery, it cannot fully replicate the emotional intelligence, pedagogical judgment, and contextual sensitivity that human educators bring to the learning process. The interaction between human and machine in pedagogical settings deserves deeper investigation, particularly concerning how AI can augment—not replace—teacher agency.

In light of these observations, future research should prioritize the development of contextualized AI frameworks that are sensitive to linguistic, cultural, and socio-economic diversity. Research should also aim to evaluate the effectiveness and unintended consequences of AI interventions on a broader scale, especially in formal school systems. Additionally, advancing ethical and inclusive policy frameworks is imperative to prevent the amplification of existing educational inequalities. Issues such as algorithmic bias, data privacy, and student autonomy must be addressed through well-defined regulatory and governance mechanisms.

Aligning AI applications in education with the human-centered values of Society 5.0—including empathy, equity, and sustainability—requires a concerted effort from researchers, practitioners, policymakers, and technology developers. Bridging the current gaps is not only a matter of technological advancement but also of ensuring that innovation genuinely serves learners of all backgrounds without reinforcing systemic disparities.

3.6 Discussion

The results of the bibliometric analysis provide significant insights into the evolution of scholarly attention on Artificial Intelligence (AI) in the educational sector, particularly within the frameworks of Industry 4.0 and Society 5.0. Based on the keyword frequency and clustering patterns, it is evident that research in this field is undergoing a paradigmatic shift—from focusing solely on technological enhancement toward more integrative, human-centered educational systems.

The rise in the number of publications in 2021 and 2022 correlates with global educational reforms and the increasing availability of digital tools [29], [30]. While earlier studies tended to emphasize automation, intelligent tutoring systems, and machine learning applications [26], [27], the clustering results in this study indicate the emergence of more diversified themes such as generative AI, sustainable education, and adaptive learning systems. These reflect a growing interest in not only improving educational delivery but also aligning it with broader social and ethical imperatives [28].

The most dominant keywords—artificial intelligence, education, Industry 4.0, and Society 5.0—serve as anchor points for the current discourse. This suggests that research has matured beyond the experimental stage and is now engaging with larger systemic questions: How should AI support educational transformation in ways that are inclusive and equitable? How does the shift from Industry 4.0's efficiency-driven paradigm to Society 5.0's human-centered innovation reshape the educational landscape?

Cluster analysis using VOSviewer reveals thematic concentrations that align with both technological and pedagogical priorities. For instance, one cluster (green) groups keywords around AI and Society 5.0, indicating the central role of ethics, equity, and human empowerment in future educational technologies. Another cluster (blue) focuses on Industry 4.0 and education, where the emphasis is on automation, smart environments, and digital competency frameworks. The appearance of keywords such as machine learning, generative AI, and chatbots in their respective clusters underscores the rapid diversification of AI tools being explored in education.

Despite this progress, several limitations are apparent in the current literature. First, the relatively low occurrence of keywords related to teacher readiness, cultural adaptation, and digital equity suggests an ongoing bias toward technologically driven solutions without adequate consideration of contextual and human factors. Second, empirical validation of AI's effectiveness remains scarce; many studies offer conceptual discussions or simulations but lack data from real-world classroom implementations, especially in non-Western or developing contexts.

The shift toward Society 5.0 calls for a reevaluation of the relationship between technology and pedagogy. Rather than viewing AI as a replacement for educators, the literature is increasingly positioning it as a facilitator of more personalized, adaptive, and inclusive learning environments. However, this vision requires deeper collaboration across disciplines—combining computer science, education, sociology, and ethics—to ensure that AI technologies are designed and deployed in ways that reflect and support local values and learning needs.

Moreover, the findings imply the need for clearer ethical frameworks and governance models. Issues such as algorithmic bias, student data privacy, and the risk of over-reliance on automated systems demand careful attention. Without rigorous policy development and inclusive design principles, there is a risk that AI in education could exacerbate existing inequalities rather than mitigate them.

In conclusion, while the current body of literature provides a strong foundation, the path forward should involve more empirical, interdisciplinary, and equity-focused research to fully realize the potential of AI in education. This is particularly crucial in the transition toward Society 5.0, where the goal is not only to leverage technology but to do so in service of holistic human development.

4. Conclusion

This bibliometric analysis provides a comprehensive overview of current research trends related to the use of Artificial Intelligence (AI) in education, particularly in the context of the shift from Industry 4.0 to Society 5.0. The findings reveal a significant increase in scholarly attention to AI applications that go beyond automation and efficiency, emphasizing themes such as adaptive learning, digital transformation, human-centered design, and ethical considerations. The clustering of keywords into domains like intelligent systems, generative AI, and sustainable education suggests that the academic discourse is gradually aligning with the vision of Society 5.0, which advocates for the integration of advanced technologies to enhance human welfare, rather than merely driving industrial productivity.

Despite its contributions, this study is not without limitations. The analysis relies solely on publications indexed through Google Scholar using the Publish or Perish tool, which may not fully reflect the most rigorous or peer-reviewed sources across databases such as Scopus or Web of Science. Additionally, the study focused on keyword co-occurrence and visualization without delving deeper into citation network analysis or content-based thematic synthesis. The language scope was also limited to English, potentially excluding important insights from regional and non-English literature. These constraints may affect the generalizability and depth of the conclusions drawn.

To build upon this research, future studies are recommended to incorporate a broader and more diverse data pool from multiple academic databases and to apply a mixed-methods approach, including full-text analysis and author co-citation networks. Further investigation is also needed in areas that appear underrepresented in the current literature, such as the development of AI tools that are culturally and linguistically contextualized, the long-term impacts of AI on actual learning outcomes in real classrooms—especially in low-resource environments—and the evolving role of teachers in AI-mediated instruction. Equally important is the formulation of inclusive and adaptive ethical frameworks that ensure AI in education does not exacerbate inequalities but instead contributes to equitable and lifelong learning opportunities.

In summary, as the world transitions toward Society 5.0, where technological advancement must coexist with human dignity and inclusivity, the integration of AI in education must be guided not only by technical innovation but also by pedagogical relevance, cultural responsiveness, and social responsibility. This study provides a strategic foundation for shaping interdisciplinary research agendas that respond to those evolving challenges and opportunities.

Author's declaration

Author contribution

Indra Pratama Putra led the conceptualization, research design, methodology development, and drafting of the manuscript. **Asrul Huda** contributed to data analysis, interpretation of findings, and supervised the overall progress of the study. **Muhammad Adri** was responsible for literature review, data collection, and assisted in the preparation and editing of the manuscript. **Dedy Irfan** supported software utilization, visualization, and contributed to the final review and validation of the research output. All authors read and approved the final version of the manuscript.

Funding statement

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors

Acknowledgements

The authors would like to express their sincere gratitude to the Department of Electronics Engineering, Faculty of Engineering, Universitas Negeri Padang, Padang, Indonesia, for their valuable support and contributions throughout the course of this research. Their academic environment, resources, and encouragement were instrumental in the successful completion of this study.

Competing interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Ethical clearance

The authors declare no competing financial or personal interests that could have influenced the outcomes of this research.

AI statement

The grammatical structure of this article was enhanced using ChatGPT to ensure clarity and academic tone. All AI-assisted outputs were thoroughly reviewed, validated, and cross-checked by the authors to ensure consistency with the research topic and data. Furthermore, the language and content of the article were verified by an English language expert, and no AI-generated sentences were included without critical revision and authorial oversight.

Publisher's and Journal's note

Universitas Negeri Padang as the publisher and Editor of Jurnal Vokasi Informatika (JAVIT) state that there is no conflict of interest towards this article publication.

References

[1] S. Timotheou *et al.*, "Impacts of digital technologies on education and factors influencing schools' digital capacity and transformation: A literature review," *Educ. Inf. Technol.*, vol. 28, no. 6, pp. 6695–6726, Jun. 2023, https://doi.org/10.1007/s10639-022-11431-8.

[2] E. Mukul and G. Büyüközkan, "Digital transformation in education: A systematic review of education 4.0," *Technol. Forecast. Soc. Change*, vol. 194, p. 122664, Sep. 2023, https://doi.org/10.1016/j.techfore.2023.122664.

[3] M. L. Nieto-Taborda and R. Luppicini, "Accelerated Digital

Transformation of Higher Education in the Wake of COVID-19: A Systematic Literature Review," *Int. J. Chang. Educ.*, vol. 2, no. 2, pp. 123–138, Sep. 2025, https://doi.org/10.47852/BONVIEWIJCE42023125.

[4] Y. Xu *et al.*, "Artificial intelligence: A powerful paradigm for scientific research," *Innovation*, vol. 2, no. 4, Nov. 2021, https://doi.org/10.1016/j.xinn.2021.100179.

[5] I. Celik, E. Gedrimiene, S. Siklander, and H. Muukkonen, "The affordances of artificial intelligence-based tools for supporting 21st-century skills:," *Australas. J. Educ. Technol.*, vol. 40, no. 3, pp. 19–38, Jun. 2024, https://doi.org/10.14742/ajet.9069.

[6] A. J. Kess-Momoh, S. T. Tula, B. G. Bello, G. B. Omotoye, and A. I. Daraojimba, "Strategic human resource management in the 21st century: A review of trends and innovations," *https://wjarr.co.in/sites/default/files/WJARR-2024-0105.pdf*, vol. 21, no. 1, pp. 746–757, Jan. 2024, https://doi.org/10.30574/WJARR.2024.21.1.0105.

[7] J. E. (Hans. Korteling, G. C. van de Boer-Visschedijk, R. A. M. Blankendaal, R. C. Boonekamp, and A. R. Eikelboom, "Human- versus Artificial Intelligence," *Front. Artif. Intell.*, vol. 4, p. 622364, Mar. 2021, https://doi.org/10.3389/frai.2021.622364.

[8] G. Zhao, Y. Li, and Q. Xu, "From Emotion AI to Cognitive AI," *Int. J. Netw. Dyn. Intell.*, pp. 65–72, Dec. 2022, https://doi.org/10.53941/ijndi0101006.

[9] I. H. Sarker, "AI-Based Modeling: Techniques, Applications and Research Issues Towards Automation, Intelligent and Smart Systems," *SN Comput. Sci.*, vol. 3, no. 2, pp. 1–20, Mar. 2022, https://doi.org/10.1007/s42979-022-01043-x.

[10] W. Strielkowski, V. Grebennikova, A. Lisovskiy, G. Rakhimova, and T. Vasileva, "AI-driven adaptive learning for sustainable educational transformation," *Sustain. Dev.*, vol. 33, no. 2, pp. 1921–1947, Apr. 2024, https://doi.org/10.1002/sd.3221.

[11] K. Wongmahesak, F. Karim, and N. Wongchestha, "Artificial Intelligence: A Catalyst For Sustainable Effectiveness In Compulsory Education Management," *Asian Educ. Learn. Rev.*, vol. 3, no. 1, pp. 4–4, 2025, https://doi.org/10.14456/AELR.2025.4.

[12] Dr. Lohans Kumar Kalyani, "The Role of Technology in Education: Enhancing Learning Outcomes and 21st Century Skills," *Int. J. Sci. Res. Mod. Sci. Technol.*, vol. 3, no. 4, pp. 05–10, Apr. 2024, https://doi.org/10.59828/ijsrmst.v3i4.199.

[13] J. Hutson and J. Ceballos, "Rethinking Education in the Age of AI: The Importance of Developing Durable Skills in the Industry 4.0," *J. Inf. Econ.*, vol. 1, no. 2, pp. 26–35, Jul. 2023, https://doi.org/10.58567/jie01020002.

[14] A. Khang, B. Jadhav, and S. Birajdar, "Industry Revolution 4.0: Workforce Competency Models and Designs," *Des. Work. Manag. Syst. Ind. 4.0 Data-*

Centric AI-Enabled Approaches, pp. 11–34, Jan. 2023, https://doi.org/10.1201/9781003357070-2.

[15] F. Kamalov, D. Santandreu Calonge, and I. Gurrib, "New Era of Artificial Intelligence in Education: Towards a Sustainable Multifaceted Revolution," *Sustain. 2023, Vol. 15, Page 12451*, vol. 15, no. 16, p. 12451, Aug. 2023, https://doi.org/10.3390/SU151612451.

[16] R. M. Oosthuizen, "The Fourth Industrial Revolution – Smart Technology, Artificial Intelligence, Robotics and Algorithms: Industrial Psychologists in Future Workplaces," *Front. Artif. Intell.*, vol. 5, p. 913168, Jul. 2022, https://doi.org/10.3389/frai.2022.913168.

[17] V. J. Owan, K. B. Abang, D. O. Idika, E. O. Etta, and B. A. Bassey, "Exploring the potential of artificial intelligence tools in educational measurement and assessment," *Eurasia J. Math. Sci. Technol. Educ.*, vol. 19, no. 8, p. em2307, Aug. 2023, https://doi.org/10.29333/EJMSTE/13428.

[18] D. M. Heeg and L. Avraamidou, "The use of Artificial intelligence in school science: a systematic literature review," *EMI. Educ. Media Int.*, vol. 60, no. 2, pp. 125–150, Apr. 2023, https://doi.org/10.1080/09523987.2023.2264990.

[19] P. Akpamah and A. Matkó, "Information Technology deployment in Human Resource Management: A case study in deprived regions," *Int. Rev. Appl. Sci. Eng.*, vol. 13, no. 1, pp. 1–10, Jul. 2021, https://doi.org/10.1556/1848.2021.00278.

[20] X. Yao, N. Ma, J. Zhang, K. Wang, E. Yang, and M. Faccio, "Enhancing wisdom manufacturing as industrial metaverse for industry and society 5.0," *J. Intell. Manuf.*, vol. 35, no. 1, pp. 235–255, Jan. 2024, https://doi.org/10.1007/S10845-022-02027-7/METRICS.

[21] I. Gagnidze, "Industry 4.0 and industry 5.0: can clusters deal with the challenges? (A systemic approach)," *Kybernetes*, vol. 52, no. 7, pp. 2270–2287, Jul. 2023, https://doi.org/10.1108/K-07-2022-1005/FULL/XML.

[22] D. A. S. George and A. S. H. George, "Towards a Super Smart Society 5.0: Opportunities and Challenges of Integrating Emerging Technologies for Social Innovation," *Partners Univers. Int. Res. J.*, vol. 3, no. 2, pp. 01–29, Jun. 2024, https://doi.org/10.5281/ZENODO.11522048.

[23] N. Donthu, S. Kumar, D. Mukherjee, N. Pandey, and W. M. Lim, "How to conduct a bibliometric analysis: An overview and guidelines," *J. Bus. Res.*, vol. 133, pp. 285–296, Sep. 2021, https://doi.org/10.1016/J.JBUSRES.2021.04.070.

[24] S. Paek and N. Kim, "Analysis of Worldwide Research Trends on the Impact of Artificial Intelligence in Education," *Sustain. 2021, Vol. 13, Page 7941*, vol. 13, no. 14, p. 7941, Jul. 2021, https://doi.org/10.3390/SU13147941.

[25] H.-C. Koong Lin *et al.*, "Transforming Education: A Comprehensive

Review of Generative Artificial Intelligence in Educational Settings through Bibliometric and Content Analysis," *Sustain. 2023, Vol. 15, Page 12983*, vol. 15, no. 17, p. 12983, Aug. 2023, https://doi.org/10.3390/SU151712983.

[26] M. Tedre *et al.*, "Teaching machine learning in K-12 Classroom: Pedagogical and technological trajectories for artificial intelligence education," *IEEE Access*, vol. 9, pp. 110558–110572, 2021, https://doi.org/10.1109/ACCESS.2021.3097962.

[27] M. Al-Emran, B. Abu-Hijleh, and A. R. A. Alsewari, "Exploring the Effect of Generative AI on Social Sustainability Through Integrating AI Attributes, TPB, and T-EESST: A Deep Learning-Based Hybrid SEM-ANN Approach," *IEEE Trans. Eng. Manag.*, 2024, https://doi.org/10.1109/TEM.2024.3454169.

[28] E. Hosseini, K. Taghizadeh Milani, and M. S. Sabetnasab, "Development and maturity of co-word thematic clusters: the field of linked data," *Libr. Hi Tech*, vol. 43, no. 1, pp. 81–113, Feb. 2023, https://doi.org/10.1108/LHT-10-2022-0488/FULL/XML.

[29] P. Dunleavy and H. Margetts, "Data science, artificial intelligence and the third wave of digital era governance," *Public Policy Adm.*, 2023, https://doi.org/10.1177/09520767231198737.

[30] C. Verma, P. Vijayalakshmi, N. Chaturvedi, U. Umesh, A. Rai, and A. Y. A. Bani Ahmad, "Artificial Intelligence in Marketing Management: Enhancing Customer Engagement and Personalization," *2025 Int. Conf. Pervasive Comput. Technol. ICPCT 2025*, pp. 397–401, 2025, https://doi.org/10.1109/ICPCT64145.2025.10940626.