Impact Of Artificial Intelligence For Sustainable Development In Higher Education: A Bibliometric Analysis

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Abstract. This study aims to analyse the existing literature on the role of AI in promoting sustainability within higher education. Through a bibliometric method and the use of VOSviewer, patterns and connections were identified, re- veal- ing four main thematic clusters. These clusters describe the integration of AI as a tool for data analysis, personalised learning and decision support in sustaina- bility. However, the potential of AI to complement human expertise is also counterbalanced by ethical considerations and the need for appropriate pedagogical training. In addition, the challenges of rapid technological change are highlighted, with a call for a continued commitment to the professional development of educators. Despite concerns about the use of AI, substantial efforts have been made by higher education institutions to integrate technological approaches, highlighting the positive impact these initiatives can have on contributing to the development of a more sustainable society. In conclusion, although promising, this integration requires ethical reflection and appropriate training. Future efforts should focus on a thorough understanding of the complexities of this relationship in order to maximise the benefits while mitigating the potential risks of this technological and educational convergence.

Keywords: Artificial intelligence, higher education, sustainability, vos viewer,bibliometric analysis

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1 Introduction

Technology, especially artificial intelligence (AI), is revolutionizing the way we live, work, and learn, emerging as a critical force in society that shapes our future with unprecedented speed and scope. The integration of AI across various sectors has been transformative, with education being no exception. The rise of AI in education marks a significant shift from traditional learning paradigms, offering new teaching and learning opportunities that cater to 21st-century demands.

The evolution of higher education has notably transitioned from traditional classroom interactions between teachers and students, where tasks were manually completed, to a more technologically integrated approach. This shift was dramatically accelerated by the global COVID-19 pandemic, which necessitated a rapid move from in-person to online learning environments worldwide. This abrupt change highlighted the versatility and necessity of technology in sustaining educational continuity during challenging periods.

AI is at the forefront of this educational transformation, providing tools and solutions that enhance educational processes and outcomes. It allows institutions to meticulously analyze operational activities, leading to improved quality and efficiency. By mimicking human cognitive functions, AI can perform a wide array of tasks, from administrative to personalized learning experiences, with the unique capability to adapt and improve based on the data it collects.

In the context of sustainable education, AI plays a pivotal role. The United Nations' 2030 Agenda for Sustainable Development emphasizes the importance of inclusive and equitable quality education as a foundation for improving lives and fostering sustainable development. AI technologies offer innovative solutions to achieve these goals, enabling access to education across diverse geographical areas and creating learning environments that are more engaging, flexible, and effective.

AI's impact on education is evident in various applications, from personalized learning paths that cater to individual student needs and preferences, to automated grading systems that save teachers time and provide immediate, actionable feedback. Virtual reality (VR) and augmented reality (AR) technologies enhance learning by offering immersive experiences, making education more engaging and accessible. Furthermore, AI redefines the role of educators, transitioning them from traditional lecturers to facilitators who guide students through personalized learning journeys.

As we delve into the intersection of AI and sustainability in higher education, it is clear that technology not only supports educational delivery but also plays a crucial role in preparing students for a future where technological fluency and sustainable thinking are paramount. AI offers the tools and frameworks necessary for educators and students to navigate the complexities of modern learning, ensuring that education systems are not only adaptable and resilient but also aligned with the principles of sustainable development.

2 THEORETICAL BACKGROUND

The interaction between artificial intelligence (AI) and sustainability within higher education offers substantial benefits. The literature highlights AI's ability to handle large and complex datasets, as outlined by Goralski and Tan (2022), facilitating the discovery of sustainability-related patterns and trends such as climate change (Nordgren, 2023), resource depletion and environmental damage (Qian et al., 2023). This analysis helps educators develop targeted teaching strategies to meet students' needs (Chen, Chen and Lin, 2020; Tell and Hoveskog, 2022). AI's role extends to personalizing learning experiences by analyzing student performance to provide accu- rate feedback and interventions, boosting engagement and results (Goralski & Tan, 2022). Despite these benefits, Adams et al. (2023) highlight the need to address the ethical challenges and concerns associated with the application of AI in sustainability education.

Recent research trends have shown a growing interest in analyzing the application of technologies in various fields of knowledge, such as education. Recent studies have highlighted the benefits of artificial intelligence (AI) in higher education (Crompton & Burke, 2023) and its application in teaching and learning processes at all levels of education, particularly in higher education where technology plays a central role in learning processes. This has led to a change in the dynamics of interaction between teachers and students (Aznar-Díaz et al., 2018). In addition, AI is helping to automate teachers' administrative tasks and serves as a learning tool for students outside the classroom (León and Viña, 2017).

In addition, there are concerns that AI will replace human knowledge and critical thinking, compromising the ability to make decisions (Burger et al., 2023). According to [1] while AI can provide valuable information and support sustainability education in higher education, it cannot replace the value of human expertise and knowledge in this area. It is important to ensure that AI is used as a tool to support and enhance human decision-making, not to replace it (Burger et al., 2023).

In the context of higher education, rapid technological change poses the challenge of ensuring that education professionals and institutions are properly equipped to incorporate and adapt to the latest trends in artificial intelligence (AI). According to Khosravi et al (2022), the integration of AI into higher education requires a continued commitment to the professional development of educators to ensure they have the skills and knowledge to effectively integrate these tools into their teaching methods, particularly to teach sustainability through AI.

Despite concerns about the use of AI technology, particularly for teaching sustainability in higher education, Leal Filho (2023a) suggests that adopting the technology is one of the strategies for improving sustainable development. Despite the challenges highlighted by [2] such as the lack of teacher training, the short- age of appropriate and up-to-date teaching materials, and the inadequacy of available infrastructure and resources, Leal Filho (2023a) suggests that one of the strategies to improve sustainable development is through the adoption of technology.

Despite facing challenges, Leal Filho et al (2023b) indicate that higher education institutions (HEIs) have made considerable efforts to integrate technological approaches in the context of higher education, highlighting the positive impact that these initiatives can have. Among other benefits, they highlight the potential contribution to the development of a more sustainable society. In this sense, the improvement of university education in terms of sustainability could be exploited in the future throughthe increased adoption of modern information technologies (Saner; Yiu; Nguyen, 2020), such as artificial intelligence in education (Keiper et al., 2023).

Therefore, it is understood that artificial intelligence represents a promising opportunity to integrate sustainability principles into the context of higher education. Despite the inherent challenges, it is crucial to take into account ethical, security and continuous updating considerations to ensure that this technology is used responsibly and contributes to the promotion of sustainable development. This article therefore aims to carry out a bibliometric analysis of scientific publications relating to the use of artificial intelligence tools in higher education, exploring how these technologies can support the teaching of sustainability and address the associated challenges, such

as the risk of replacing human judgement and the need for adequate teacher training. This approach will identify trends, research gaps and future directions for the responsible and effective use of artificial intelligence in promoting more sustainable higher education.

3 Methodology

The methodology of this study is descriptive. A bibliometric analysis was used to provide an overview of existing production in the field of IA and sustainable devel- opment in higher education.

Bibliometric analysis refers to a methodology used to describe and analyse the scientific output published in a field of research as well as its citations, authors, institutions, publication sources, and disciplines (Li et al., 2019; Mutschke et al., 2011). The bibliometric method makes it possible to manage a significant number of scientific productions through graphical illustration and implements a structured, repeatable andclear review procedure (Zupic & Čater, 2015).

For this study, scientific articles found in the Scopus database were used, considered a valid source providing reliable data on global scientific production for speci- fied periods, with a disciplinary focus and peer review (Gao et al., 2022).

The search equation used was : *TITLE-ABS-KEY ("artificial intelligence" AND "higher education" OR "higher education for sustainability") AND PUBYEAR > 2013 AND PUBYEAR < 2023 AND (LIMIT-TO (SUBJAREA , "BUSI")) AND (LIMIT-TO (EXACTKEYWORD , "Artificial Intelligence") OR LIMIT-TO (EXACTKEYWORD , "Higher Education") OR LIMIT-TO (EXACTKEYWORD , "High Educations") OR LIMIT-TO (EXACTKEYWORD , "Sustainable Development") OR LIMIT-TO (EXACTKEYWORD , "Sustainability")) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp")) AND (LIMIT-TO (LANGUAGE , "English")).*

Data collection for this study took place over a ten-year period, from 2013 to 2023, in order to analyse the relevant literature and obtain a comprehensive understanding of the subject under study. Initially, 2318 documents were identified as potentially relevant. After applying the search equation, publications not corresponding to the study period of 2013 to 2023 were eliminated.

Additional filtering was performed on the database, limiting the selection to journal articles and conference papers, and restricting the selection to documents published in English. The keywords used to refine the search were "artificial intelligence", "higher education", "sustainable development", "sustainability", and the specific field of research selected was business, management and accounting. This methodical approach made it possible to reduce the initial number of documents to 83 publications finally selected for analysis, after excluding 2235 documents that did not meet the estab- lished criteria.

The documents were then analysed using VOSviewer software. According to Anholon et al (2022), VOSviewer is widely used in bibliometric studies. Its functionality consists of performing analyses by generating network maps, which make it possible to identify patterns, clusters and trends present in a given data set. Contributions can be made from data contained in scientific databases; alternatively, data can be import-ed from RIS, EndNote and via CSV files, (VAN ECK; WALTMAN, 2020). In this study, the data was imported into VOSviewer from the scopus database.

The following indicators were applied to the bibliographic data of the 83 publications for a detailed analysis:

Publication history: This indicator shows the number of publications made per year, allowing us to visualise the trend and growth of interest in artificial intelligence in the field of study over time, reflecting the evolution of research in this area.

Citations: Reveals the number of citations received by publications and highlights the main contributions within the whole. This indicator is essential for identifying the most influential and widely recognised articles in the field, highlighting studies that have had a significant impact on subsequent research.

Publications by country: this indicator shows the number of publications produced by each country, providing a perspective on which regions have the most research activity and contributions to the field of study. This analysis can reveal how artificial intelligence research is distributed geographically and which are the main research centres in the world.

Publication sources: presents the main journals in which articles have been published, making it possible to identify the most relevant publications with the greatest impact on the dissemination of knowledge on artificial intelligence and sustainability in the field of higher education. Knowing which journals are the most prestigious can guide future researchers in publishing their work.

Sponsors: indicates who funded the research behind the publications. This indicator is fundamental to understanding the financial support networks behind the research, revealing the entities or institutions that prioritise and promote the study of artificial intelligence and sustainability.

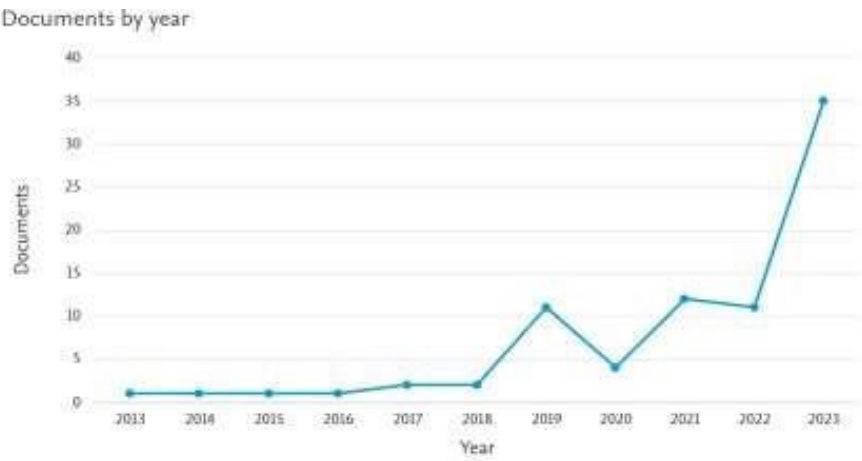
Keywords: Conduct a keyword analysis using the association strength method, as suggested by Sánchez-Céspedes et al. (2020). The aim of this approach is to identify the main thematic categories and their interrelationships, making it possible to discern research trends, predominant centres of interest and the evolution of topics within the field of study.

4 RESULTS:

The presentation of the results was structured around six different approaches: the evolution of publications over time, citation analysis, geographical distribution by country, publication journals, funding bodies and the study of keywords.

4.1 Documents by year

Fig.1. Publication history of artificial intelligence, sustainability in higher education in Scopus (2013-2023)



Source: Scopus

Figure 1 shows the temporal distribution of scientific publications devoted to the use of artificial intelligence and sustainability in higher education over a decade, from2013 to 2023. This diachronic profile reveals an exponential increase in research out- put, reflecting a gradual and growing interest in this disciplinary field.

The publication rate in 2013, with a single article, indicates that the intersection of AI and higher education was at an embryonic stage of recognition and exploration. Subsequent years show a slight increase in 2014, followed by a period of fluctuations until 2017, during which the number of publications stabilises at around 9 per year, indicating a gradual maturation of research in the field.

The upward trend becomes more pronounced from 2018 onwards, reaching a notable peak in 2023 with the publication of 35 articles. This upward trend can be interpreted as a manifestation of growing academic recognition of the strategic relevance and innovation potential of AI and sustainability in higher education, signalling its

consolidation as a research priority and its potential to influence pedagogical and administrative practices in academic institutions.

The following table presents the ten most cited articles in the corpus of our study, providing an overview of the themes that dominate the landscape of AI and sustainability in higher education. These articles have been selected for their high relevance, their contribution to understanding the opportunities and challenges posed by AI and their role in shaping the future vision of education.

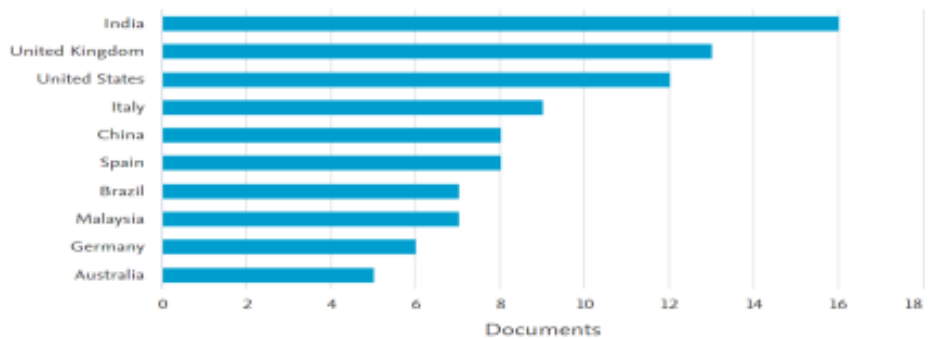
4.2 Top articles most cited

Document title	Authors	Source	Year	citations
Exploring the impact of artificial intelligence on teaching and learning in higher education	Popenici, S.A.D., Kerr, S.[3]	Research and Practice in Technology Enhanced Learning, 12(1), 22	2017	412
Embracing Digitalization: Student Learning and New Technologies	Crittenden, W.F., Biel, I.K., Lovely, W.A.[4]	Journal of Marketing Education, 41(1) pp. 5–14	2019	90
Implications of AI (un-)fairness in higher education admissions: The effects of perceived AI (un-)fairness on exit, voice and organizational reputation	Marcinkowski,F., Kieslich,K., Starke, C., Lünich, M.[5]	FAT* 2020 - Proceedings of the 2020 Conference on Fairness, Accountability, and Transparency, pp. 122–130	2020	78
Critical attributes of Sustainability in Higher Education: A categorisation from literature review	Viegas, C.V., Bond, A.J., Vaz, C.R.,Selig,P. M., Varvakis, G.[6]	Journal of Cleaner Production, 126, pp. 260–276	2016	65
Big data analytics capability for improved performance of higher education institutions in the Era of IR 4.0: A multi-analytical SEM & ANN perspective.	Ashaari, M.A., Singh, K.S.D., Abbasi, G.A., Amran ,A., Liebana-Cabanillas, F.J.[7]	Technological Forecasting and Social Change, 173, 121119	2021	64

Technologies of improving the uni-versity efficiency by using artificial intel- ligence: Motivational aspect	Vinichenko, M.V., Melnichuk, A.V., Karácsony, P.[8]	Entrepreneurship and Sustainability Issues, 7(4), pp. 2696–2714	2020	24
Change to competence-based education in structural engineering	De Justo ,E., Delgado, A.[9]	Journal of Professional Issues in Engineering Education and Prac- tice, 141(3), 5014005	2015	22
On the Educational Impact of ChatGPT: Is Artificial Intelligence Ready to Obtain a University Degree?	Malinka, K., Peresíni,M., Firc, A., Hujnák, O., Janus, F.[10]	Annual Conference onInnovation and Technology in Computer Science Education, ITiCSE, 1, pp. 47–53	2023	21
E-Commerce Assistance with a Smart Chatbot using Artificial Intelligence	Rakhra, M., Gopinadh,G., Addepalli,N.S., ...Reddy,V.S.G., Reddy, M.N.[11]	Proceedings of 2021 2nd International Conference on Intelligent Engineering and Management, ICIEM 2021, pp. 144–148, 9445316	2021	18
ARTIFICIAL INTELLIGENCE CHATBOTS FOR LIBRARY REFERENCE SERVICES	Nawaz, N., Saldeen, M.A.[12]	Journal of Management Information and Decision Sciences, 23, pp. 442–449	2020	17

4.3 Publications by country

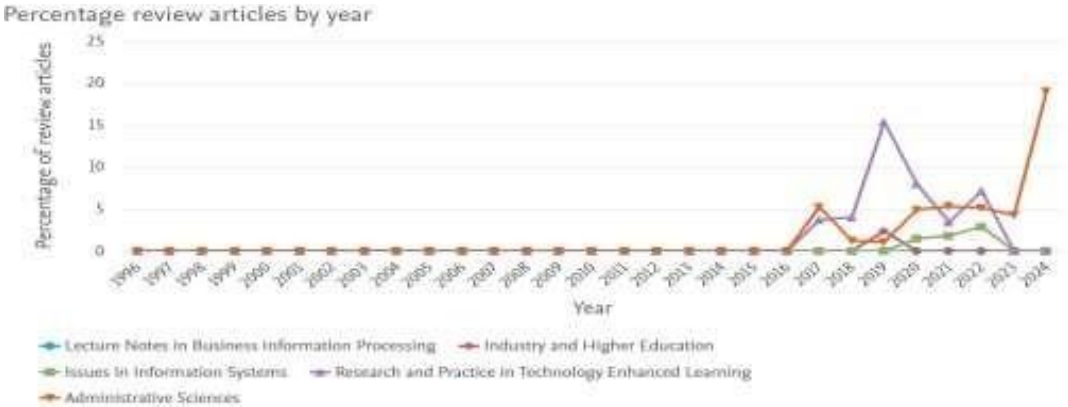
Fig.2. publications by country



With regard to the geographical location of these publications, Figure 2 shows the 10 countries with the highest number of articles published in this field.

This bar chart shows the number of documents produced by different countries. India leads the way with the highest number, followed by the UK, the US and other countries. This type of chart is often used to compare quantities between different categories; in this case, the countries and provide a clear visual indication of how theystack up against each other in terms of document production.

4.4 Publication sources



The graph we are examining plots the percentage of review articles published annually in four academic journals, covering the period from 1996 to 2024. The chart reveals notable variations in the output of scientific journals, indicating fluctuating trends in research interest and focus.

The Industry and Higher Education journal shows moderate peaks in 2013 and 2014, with little activity before and after these years until a slight rebound in 2022. This may reflect a variation in the topics of interest to this sector or the availability of significant journal work.

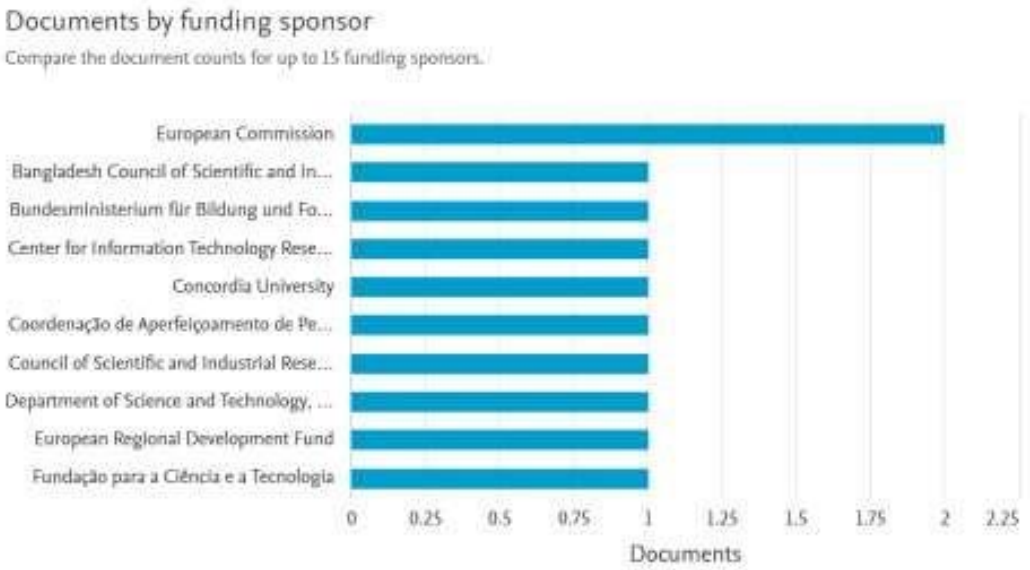
Lecture Notes in Business Information Processing show occasional spikes in publications, with a particularly striking peak in 2024. This suggests an increase in activity in this area, perhaps due to new directions in research or recent developments in the field of artificial intelligence and sustainability.

"Issues in Information Systems" shows a more regular and consistent presence of journal publications, indicating a stable interest in in-depth analysis in this field. For its part, "Research and Practice in Technology Enhanced Learning" shows a signifi- cant peak in 2021, which could correspond to a concentration of interest or to anevent that has stimulated publication in this period.

The graph as a whole shows a dynamic academic landscape, with certain key moments marking an increase in journal publication activity. The sudden spike in 2024,

which is particularly noticeable in Lecture Notes, prompts us to ask what changes or emerging trends are influencing this field of study.

4.5 Document by funding sponsors



The bar chart entitled "Documents by funding sponsor" highlights the financial contributions of sponsors in the field of AI and sustainability applied to higher education. The data suggests that the European Commission predominates as the main fun- der, with the highest number of documents associated with its funding. This is indicative of its strong commitment to supporting research and development in technological innovation.

Significant contributions from the Bangladesh Council of Scientific and Industrial Research and the Bundesministerium für Bildung und Forschung also reveal their active involvement in funding research projects. The contributions from these bodies, although fewer in number than those from the European Commission, show a clear interest in technological progress in education.

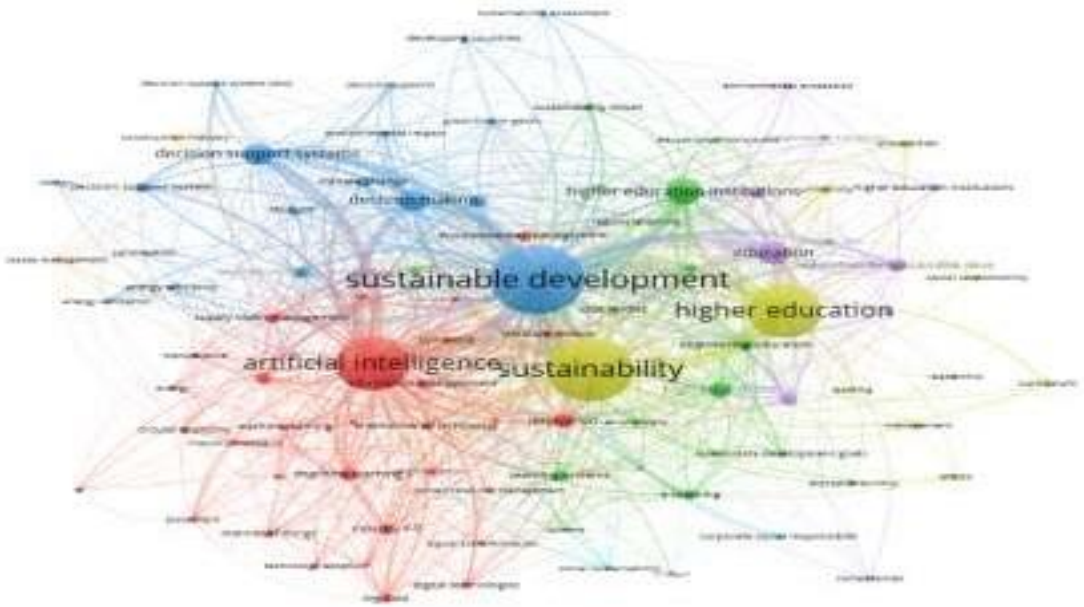
Other sponsors such as the Center for Information Technology Research, Concordia University and the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) are represented with a moderate level of funding, while institutions such as the Council of Scientific and Industrial Research, the Department of Science and Technology in India, the European Regional Development Fund and the Fundação para a Ciência e a Tecnologia show a smaller but not negligible involvement.

The distribution of sponsors reveals a collaboration between various bodies, ranging from government institutions to universities and regional funds, all of which recognise the importance of integrating AI and sustainability into higher education

through their financial support. The diversity of sponsors from different regions highlights a global interest in the advances and challenges of AI technologies in the education sector.

5 Bibliometric analysis:

5.1 co-occurrence of keywords



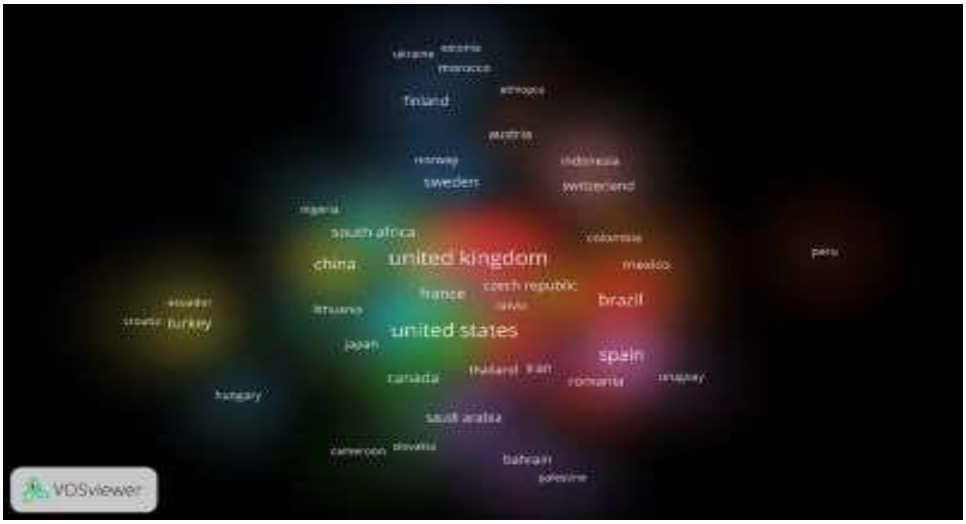
As part of the bibliometric research using the VOSviewer software, a visualisation of the co-occurrences of keywords in the literature dedicated to the intersection of artificial intelligence (AI), higher education and sustainable development was carried out. This mapping of key terms reveals the dominant themes and their interrelation- ships in the scientific corpus analysed, highlighting the main lines of research andtheir potential implications in these interdependent fields.

The terms 'artificial intelligence', 'sustainability', 'sustainable development' and 'higher education' emerge as central concepts, indicating not only leading areas of research but also significant points of convergence between advanced technologies and sustainability objectives in education. The proximity of 'artificial intelligence' to

terms such as 'machine learning' and 'big data' testifies to the growing integration ofAI in the processing and analysis of voluminous and complex data, which is particu- larly relevant in the context of optimising decision-making processes linked to sus- tainable development.

The links between "sustainable development" and concepts such as "environmental management" and "sustainability assessment" reflect a focus on environmental as- sessment and management strategies within higher education institutions. This com- plex network of terms illustrates the multiplicity of approaches and issues associated with the implementation of AI as a tool for sustainable progress in education.

5.2 Map density by country



The density map shown illustrates the co-occurrence of countries in the scientific literature analysed, presumably focused on artificial intelligence and sustainable de- velopment in the context of higher education. Countries that appear with a larger font size, such as the United States, the United Kingdom, Canada and France, appear to have a higher density of publications or collaborations, indicating a high concentra- tion of research conducted or funded by these nations.

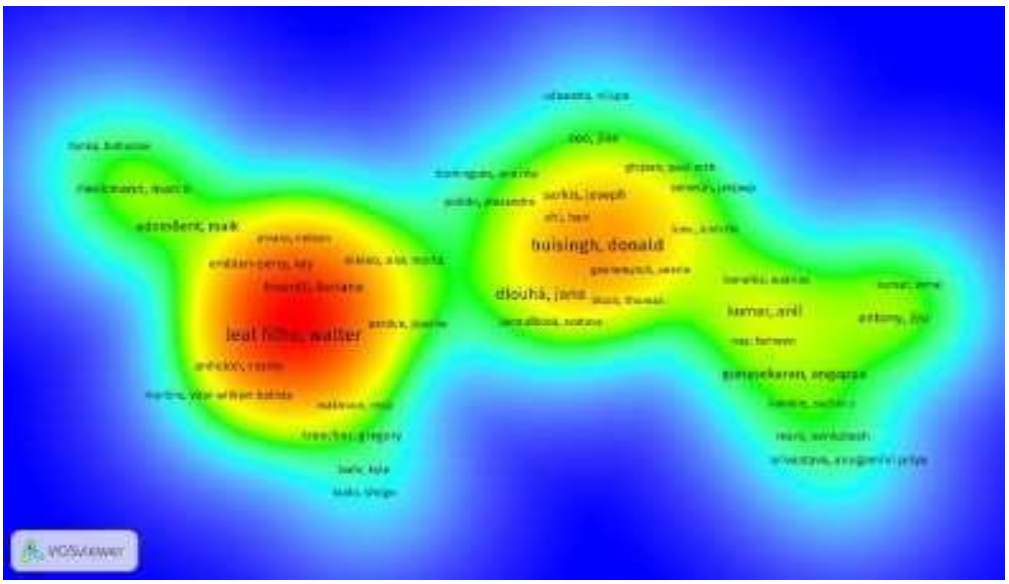
The shades of colour may represent the intensity of the contribution or the frequen- cy of international collaborations in the field concerned. Countries displayed with warmer shades, such as Spain and Brazil, can be interpreted as having a significant, though potentially less central involvement than nations with larger names.

Countries whose names appear in smaller fonts, such as Ethiopia, Cameroon and Peru, could indicate an emerging presence or more specialised contributions to the

research corpus. This may reveal specific research partnerships or areas of particular interest for these regions.

This visualisation suggests a heterogeneous distribution of AI research applied to higher education, with certain countries dominating the scientific discourse. Thisdisparity may also reflect inequalities in access to research resources, R&D invest- ment, or political and educational priorities on a global scale.

5.3 co-occurrence of density by co-authors



This VOSviewer density map illustrates the network of co-authors in the field of research probably related to artificial intelligence, sustainable development or higher education. Names in larger font, such as "Leal Filho, Walter",[13] indicate authors whoare likely to be highly influential in the field, marked by a high number of publications or collaborations.

The colours on the map show the density of collaboration between authors, with hotter areas, such as those centred around '[14] suggesting particularly active co-authorship clusters or clusters central to the research network. In contrast, authors represented in colder areas, such as "[15] or "Srivastava, Anu- gamini Priya", although part of the network, appear to have less dense co-authorship links or are perhaps emerging authors in the field.

This visualisation provides an overview of significant research collaborations and contributions. It can help identify opinion leaders, influential research teams and new voices in the field of study. Central authors and their collaborative networks could also indicate partnership opportunities or trends in research topics.

6 Discussions and conclusion

The aim of this study was to examine the link between artificial intelligence and sustainability in the context of higher education by reviewing the existing scientific literature. The results of this study confirm that this objective has been achieved. The use of VOSviewer for the analysis facilitated the identification of four distinct thematic clusters that summarise the interaction between the themes examined. In addition, the literature review highlighted the deep infusion of AI into higher education and its relevance to sustainable development initiatives. Based on these findings, several conclusions can be drawn.

Bibliometric analysis using VOSviewer software has highlighted four key thematic clusters, demonstrating an intrinsic relationship between artificial intelligence and sustainability in higher education. The first cluster illustrates the direct interaction between AI and decision support systems, highlighting the importance of informed decision-making in sustainable management. The second cluster focuses on the application of AI in higher education institutions, emphasising the role of AI as a catalyst for pedagogical innovation and administrative management.

The third cluster addresses environmental sustainability and sustainable development, highlighting the potential of AI to address issues related to climate change and environmental protection. Finally, the fourth cluster focuses on education itself, showing the impact of AI on teaching and learning strategies and their alignment with sustainable development goals.

These results corroborate the ideas put forward in the existing literature, which highlight the deep integration of AI technologies in higher education and their link with sustainable development. AI is presented not only as a tool for analysis and optimisation, but also as a means of improving the personalisation of learning and automating administrative tasks, while at the same time raising ethical and practical concerns.

The research presented here has certain limitations. First, the scope of the study is limited to articles indexed in the Scopus database, which excludes potentially relevant contributions from other academic databases. Secondly, the selection of keywords could influence the formation of clusters, omitting related terms that could have offered a deeper understanding of the sub-themes. Finally, the reliance on English publications limits the global perspective, as important research in other languages is not considered.

For future research, it would be relevant to extend the bibliometric analysis to other databases and to include a wider variety of multilingual publications to obtain a more complete picture of the research landscape. In addition, the integration of qualitative methodologies could offer further insights into the context and quality of AI interventions in sustainable education. It would also be interesting to follow the evolution of AI integration in sustainability-related curricula and to examine the long-term impact of these technologies on student skills and learning outcomes.

This study has revealed a robust integration and dynamic interaction between artificial intelligence and sustainability in higher education, marked by diverse interna-

tional contributions. While promising, this integration requires ethical reflection and appropriate pedagogical training. Future efforts should focus on deepening our under- standing of the complexities and nuances of this relationship, in order to maximise thebenefits while mitigating the potential risks of this technological and educational con- vergence.

Reference.

[1] A. Singh, A. Dwivedi, D. Agrawal, and D. Singh, "Identifying issues in adoption of AI practices in construction supply chains: towards managing sustainability," *Operations Management Research*, vol. 16, no. 4, pp. 1667–1683, 2023, doi: 10.1007/s12063-022-00344-x.

[2] M. Mansoursamaei, M. Moradi, R. G. González-Ramírez, and E. Lalla-Ruiz, "Machine Learning for Promoting Environmental Sustainability in Ports," *J Adv Transp*, vol. 2023, 2023, doi: 10.1155/2023/2144733.

[3] S. A. D. Popenici and S. Kerr, "Exploring the impact of artificial intelligence on teaching and learning in higher education," *Res Pract Technol Enhanc Learn*, vol. 12, no. 1, 2017, doi: 10.1186/s41039-017-0062-8.

[4] W. F. Crittenden, I. K. Biel, and W. A. Lovely, "Embracing Digitalization: Student Learning and New Technologies," *Journal of Marketing Education*, vol. 41, no. 1, pp. 5–14, 2019, doi: 10.1177/0273475318820895.

[5] F. Marcinkowski, K. Kieslich, C. Starke, and M. Lünich, "Implications of AI (un-)fairness in higher education admissions: The effects of perceived AI (un-)fairness on exit, voice and organizational reputation," in *FAT* 2020 - Proceedings of the 2020 Conference on Fairness, Accountability, and Transparency*, 2020, pp. 122–130. doi: 10.1145/3351095.3372867.

[6] C. V. Viegas *et al.*, "Critical attributes of Sustainability in Higher Education: A categorisation from literature review," *J Clean Prod*, vol. 126, pp. 260–276, 2016, doi: 10.1016/j.jclepro.2016.02.106.

[7] M. A. Ashaari, K. S. D. Singh, G. A. Abbasi, A. Amran, and F. J. Liebana-Cabanillas, "Big data analytics capability for improved performance of higher education institutions in the Era of IR 4.0: A multi-analytical SEM & ANN perspective.," *Technol Forecast Soc Change*, vol. 173, 2021, doi: 10.1016/j.techfore.2021.121119.

[8] M. V. Vinichenko, A. V. Melnichuk, and P. Karácsony, "Technologies of improving the university efficiency by using artificial intelligence: Motivational aspect," *Entrepreneurship and Sustainability Issues*, vol. 7, no. 4, pp. 2696–2714, 2020, doi: 10.9770/jesi.2020.7.4(9).

[9] E. De Justo and A. Delgado, "Change to competence-based education in structural engineering," *Journal of Professional Issues in Engineering Education*

and Practice, vol. 141, no. 3, 2015, doi: 10.1061/(ASCE)EI.1943-5541.0000215.

[10] K. Malinka, M. Peresíni, A. Firc, O. Hujnák, and F. Janus, "On the Educational Impact of ChatGPT: Is Artificial Intelligence Ready to Obtain a University Degree?," in *Annual Conference on Innovation and Technology in Computer Science Education, ITiCSE*, 2023, pp. 47–53. doi: 10.1145/3587102.3588827.

[11] M. Rakhra *et al.*, "E-Commerce Assistance with a Smart Chatbot using Artificial Intelligence," in *Proceedings of 2021 2nd International Conference on Intelligent Engineering and Management, ICIEM 2021*, 2021, pp. 144–148. doi: 10.1109/ICIEM51511.2021.9445316.

[12] N. Nawaz and M. A. Saldeen, "ARTIFICIAL INTELLIGENCE CHATBOTS FOR LIBRARY REFERENCE SERVICES," *Journal of Management Information and Decision Sciences*, vol. 23, pp. 442–449, 2020.

[13] A. Haleem, M. Javaid, I. H. Khan, and S. Mohan, "Significant Applications of Artificial Intelligence Towards Attaining Sustainability," *Journal of Industrial Integration and Management*, vol. 8, no. 4, pp. 489–520, 2023, doi: 10.1142/S2424862223500331.

[14] K. Walczak and W. Cellary, "Challenges for higher education in the era of widespread access to Generative AI," *Economics and Business Review*, vol. 9, no. 2, pp. 71–100, 2023, doi: 10.18559/ebr.2023.2.743.

[15] M. Dora, A. Kumar, S. K. Mangla, A. Pant, and M. M. Kamal, "Critical success factors influencing artificial intelligence adoption in food supply chains," *Int J Prod Res*, vol. 60, no. 14, pp. 4621–4640, 2022, doi: 10.1080/00207543.2021.1959665.