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Research Trends of Artificial Intelligence In Science Education: A Scopus-Based Bibliometric Mapping Using Vosviewer

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ABSTRACT

The rapid advancement of Artificial Intelligence (AI) has significantly transformed educational practices, particularly in science education, through the integration of intelligent technologies such as machine learning, natural language processing, and ChatGPT. These technologies have enabled more adaptive, personalized, and technology-enhanced learning experiences. However, comprehensive mapping of emerging research trends and thematic developments in AI-based science education remains limited. Therefore, this study aims to analyze publication trends, identify dominant research themes, and explore the development of AI technologies in science education through a bibliometric approach. This study employed bibliometric analysis using data collected from the Scopus database. A total of 270 English-language journal articles published between 2018 and 2025 were analyzed using VOSviewer software. The findings identified 102 keywords grouped into six major clusters, including (1) science education and teaching, (2) computing and education, (3) learning outcomes and educational applications, (4) language models and emerging AI technologies, (5) machine learning and intelligent systems, and (6) interdisciplinary and technology-enhanced education. Recent studies increasingly focus on ChatGPT, generative artificial intelligence, and machine learning, indicating a shift from

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traditional AI applications toward adaptive and intelligent learning environments. The findings also reveal that AI research in science education is becoming increasingly interdisciplinary and technology driven. This study contributes to providing a comprehensive overview of research development and offers insights into future directions for AI implementation in science education.

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1. INTRODUCTION

The rapid development of the 21st century has significantly transformed various aspects of human life, including education, through the integration of emerging technologies (Kasman, 2025). One of the technologies that is growing very quickly is Artificial Intelligence (AI). According to Chen et al. (2020), AI is a technology that allows computers to mimic human thinking abilities, including in recognizing patterns, analyzing information, making decisions, and generating data automatically. In the world of education, AI is starting to be applied in various platforms and digital learning environments to produce a more adaptive, personalized, and interactive learning process. In the context of science education, AI is increasingly being used to improve the effectiveness of the learning process, student engagement, and understanding of complex scientific concepts (AlKanaan, 2022) by supporting simulation-based learning methods, virtual labs, and others (Zawacki-Richter et al., 2019).

Research on AI in science education has shown a significant increase in recent years. Zhai and Krajcik (2022) found that the application of machine learning can be used to automatically assess science models created by students. In addition, many studies have investigated the application of AI in science curriculum learning, assessment, and development (Al Darayseh, 2023; Holmes and Tuomi, 2022; Xu and Ouyang, 2022). This indicates that AI has become one of the important aspects of modern educational transformation. Various studies have also revealed that AI has a positive impact on the science learning process. Wu and Tegmark (2019) observed that the application of AI in physics learning can increase students' engagement and conceptual understanding. Meanwhile, Lolinco & Holme (2024) explained that AI-based chatbots are effective in supporting the chemistry learning process and improving student learning outcomes. On the other hand, Yilmaz (2024) emphasized that AI has great potential to create a more personalized and adaptive learning experience, which can help students achieve better learning outcomes.

Not only in learning, AI is also beginning to be applied in various science education innovations, such as virtual reality, augmented reality, adaptive learning systems, and AI-based analysis of students' emotional expressions (Dimitriadou and Lanitis, 2023). Research by Huang and Qiao (2022) shows that integrating STEM education in AI learning can improve students' computational thinking skills, learning motivation, and confidence. In fact, Cooper (2023) stated that ChatGPT has the potential to be a tool that helps teachers in compiling teaching materials, rubrics, and evaluation of the science learning process.

Although research on AI in education continues to grow rapidly, studies that specifically map AI research trends in science education are still quite limited (Akhmadieva et al., 2023). Previous studies have explored the integration of AI by showing the results obtained from personalized learning. However, the fact is that bibliometric studies that focus on AI in education do not cover themes such as generative AI and thematic evolution. Therefore, research trends are needed to map out what the future research direction will look like. In addition, previous studies have emphasized the application of AI in learning rather than a comprehensive analysis of the development of the research world. Meanwhile, the rapid advancement of AI technology has resulted in the theme of research, the focus of the study, and the direction of technological development constantly changing from time to time. Therefore, bibliometric analysis is needed to map publication trends, key research themes, developments in AI technology, as well as collaboration in research in the field of science education.

Bibliometric analysis is very important because it can provide a systematic overview of the progress of a research field by analyzing scientific publications, keywords, cooperative relationships, and trends in research topics. Therefore, bibliometric studies related to Artificial Intelligence in science education are expected to provide insight into the direction of research progress, future research opportunities, as well as the role of AI in the transformation of science education. In line with this explanation, the purpose of this study is to analyze the trend of publications in research related to Artificial Intelligence in science education, identify the main themes and focuses of research, and map the advancement of AI technology in science education with a bibliometric approach.

Research questions are

- a. How have research publication trends on Artificial Intelligence in science education evolved over time?
- b. What are the dominant themes and research focuses in Artificial Intelligence studies within science education?
- c. What future research directions can be identified from the bibliometric mapping of Artificial Intelligence in science education?

2. METHODS

This study uses a bibliometric approach with the aim of analyzing and mapping the development of a field of science about the trend of using AI in science education. This approach makes it possible to identify publication trends, dominant research themes, topic developments, as well as patterns of research collaboration based on scientific publication data through quantitative analysis and data visualization techniques. Bibliometrics is particularly relevant in a rapidly growing field driven by advanced AI technologies and digitally mediated learning environments. This method is widely used to evaluate the development of a research field in a systematic and measurable manner (Zawacki-Richter et al., 2019). The research data was obtained from the Scopus database because it chose a wide reputable international coverage and provided complete metadata as bibliometric analysis material. Data collection will be carried out in 2026. The data search process is carried out using keywords related to Artificial Intelligence and science education. The search queries used are as follows TITLE-ABS-KEY ("artificial intelligence" OR "chatgpt" OR "generative AI") AND TITLE-ABS-KEY ("science education" OR "science learning" OR "science teaching" OR "STEM education"). The query above is used to obtain articles relevant to the development of AI in science education and STEM education. The term is used in limited use, this is because it is to maintain the focus of

studies on AI research in the context of science education. To ensure the representativeness of the search strategy, some of the articles found are manually checked and compared with major publications in the field. The validation process confirms that the query effectively captures the relevant literature by minimizing the publications obtained. The first 50 articles found were manually screened to evaluate their relevance and ensure alignment with the objectives of this bibliometric research. This study uses several inclusion and exclusion criteria to ensure that the data obtained is relevant to the research objectives, which are in accordance with the table below:

Table 1. Selection Criteria

Inclusions	Exclusion
The article discusses Artificial Intelligence, ChatGPT, or machine learning in the context of science education or STEM education.	Documents other than journal articles, such as conference papers, book chapters, editorials, notes, and short reviews.
Articles are indexed in the Scopus database.	Articles that do not focus on the field of science education or STEM education.
The article was published in the range of 2018–2025.	The article is duplicate or has incomplete metadata.
Articles in English.	Articles are not in English.
The type of document is in the form of a journal article.	Articles that are not fully accessible in the Scopus database.
The article has complete metadata, such as the author's name, year of publication, abstract, keywords, and publication source.	Articles with general AI topics but not related to the educational context.

After the initial search results, a number of publications were then selected based on inclusion and exclusion criteria. After the screening process was carried out, as many as 270 articles were obtained which were used as research data with the selection process as a series using the PRISMA framework.

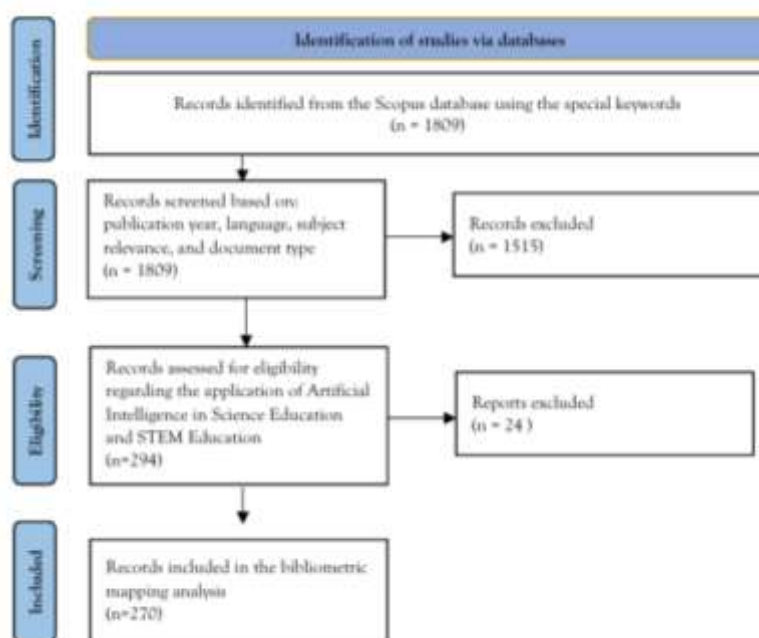


Figure 1. Study Flow Diagram

The bibliographic data obtained were analyzed using the VOSviewer software to visualize the research network and topic development. The analysis is carried out through several stages, namely: analysis of annual publication trends, keyword co-occurrence analysis, co-authorship analysis, analysis of publication sources, analysis of the development of the research theme (thematic evolution). Before analysis, duplicate keywords and synonymous terms are manually filtered and combined to improve data consistency. Of the identified keywords, 26 met the threshold criteria and were included in the visualization network. The results of the analysis are then interpreted to describe the development of Artificial Intelligence research in science education and identify future research directions.

3. RESULTS AND DISCUSSION

a. Publication Trend Analysis

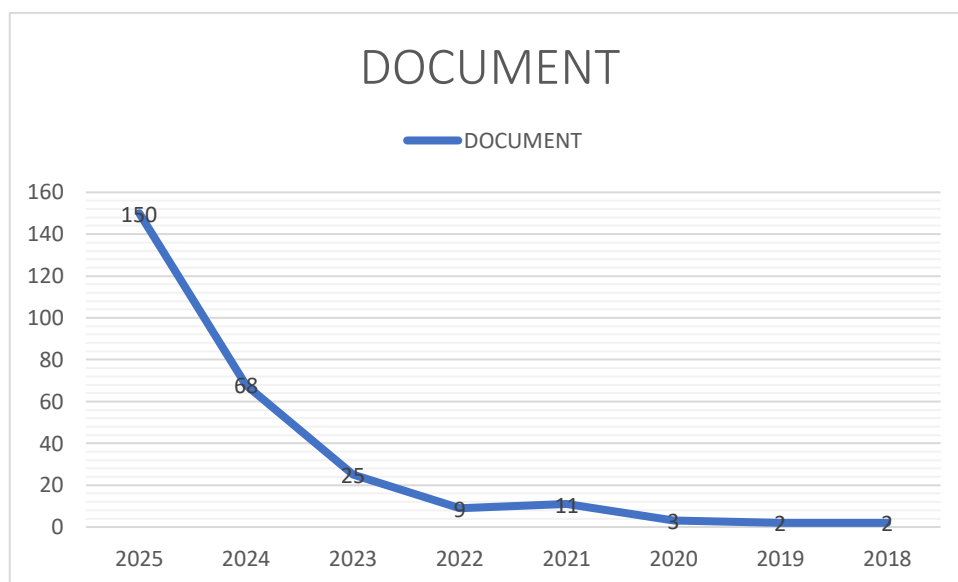


Figure 2. Annual publication trends of Artificial Intelligence research in science education

Figure 2 above is an illustration of how the development of publications on AI in science education from 2018 to 2025. The image above shows a substantial increase in the trend of publications in recent years, this can be used as data to show the interest in AI research in the world of education, especially in the special theme of science education.

b. Bibliometric Characteristics

Table 2. Bibliometric characteristics of analyzed publications

Item	Result
Database	Scopus
Total publications	270
Analysis software	VOSviewer 1.6.20
Number of keywords	102
Number of clusters	6

Cluster 2: Computing & Education

This cluster is dominated by the keyword computer science education which shows that there is a strong relationship between AI and technology education, especially computer science. If it is associated with science, then learning can be done based on data. Xu and Ouyang (2022) said that with AI, it can encourage the state or process of meeting, concentrating, or uniting various things towards the same point. With this, learning is not only centered on purely science content, but can also develop technological skills.

Cluster 3: Learning Outcomes

In this cluster, it is dominated by keywords such as learning, student and assessment. This shows that the impact of Ai is focused on the learning outcomes and evaluations carried out. Wu & Tegmark (2019) by using Ai, it can improve students' conceptual understanding and engagement in learning. This is because of the learning personalization system that facilitates students. Mahroof et al. (2020) also said that the impact of AI can also be felt in evaluating student results, by using chatbots and the application of machine learning, it can automatically assess students' answers. So the response given can be quick and direct (Zhai & Krajcik, 2022).

Cluster 4: Language Models

This cluster is dominated by keywords such as natural language processing (NLP) and language model. This shows the latest research trends using generative AI in science education, especially the one that is currently rampant, namely ChatGPT.

The existence of ChatGPT helps students understand concepts that are initially quite difficult to understand become easier. Searching for information is also easier, it supports a responsive student learning experience. Cooper (2023) said that with ChatGPT, it makes it easier for teachers to prepare lesson plans, question rubrics, and evaluations, especially in learning science.

Cluster 5: Machine Learning

This cluster is dominated by keywords such as machine learning and deep learning. This shows that Ai is still the main foundation in the development of learning innovations.

Zhai & Krajcik (2022) explain that with AI enabling automated assessment of science lessons, this can save time and be more efficient. In addition, deep learning, which is increasingly used and intensified in Indonesia for mindful, meaningful and joyful learning, is also quite closely related to AI. Where learning will be more adaptive and requires students to be smart (Jiang, 2025).

Cluster 6: Emerging Technologies

This cluster is dominated by keywords such as augmented reality and virtual reality. This shows that AI research is beginning to be integrated with immersive technology, particularly in science education. According to Lumbantoruan et al. (2025), the use of augmented reality and virtual reality allows learning to be more real and interactive. So that abstract science concepts can use this immersive technology. The combination of this technology with AI can increase student involvement in learning and improve understanding of scientific concepts that are quite complex (Dimitriadou & Lanitis, 2023; FitzGerald et al., 2013).

From the explanation of some of the clusters above, it is necessary to have a clearer picture of the identified research themes, Table 3 below summarizes the main keywords

and research focuses represented in each cluster. Although each cluster exhibits different thematic characteristics, it collectively and collectively illustrates how the use of AI in science education is developing.

Table 3. Summary of research themes identified from keyword clusters

Cluster	Main Keywords	Research Focus
Cluster 1 (Red)	Science education, teaching, students, STEM education, AI	Learning practices and instructional processes
Cluster 2 (Green)	Education, learning, assessment, curriculum, human	Educational applications and learning evaluation
Cluster 3 (Blue)	Education computing, computer science education, software engineering	Computational and technological integration
Cluster 4 (Purple)	Machine learning, deep learning, natural language processing, learning algorithms	Data-driven and intelligent learning systems
Cluster 5 (Yellow)	Large language model, personalized learning, computational linguistics, robotics	Emerging AI applications and adaptive learning
Cluster 6 (Cyan)	Artificial intelligence, technology, science technologies, mathematics education, engineering	Technology-enhanced and interdisciplinary education

The findings from the table above show that AI research in science education is increasingly moving towards a more integrated, adaptive, and innovative learning environment.

d. Research Trends

The results of the overlay visualization show that the latest research in the field of AI in science education highlights keywords such as ChatGPT, Generative Ai, and machine learning. These findings show a shift in research trends from conventional AI to generative AI that is more interactive and natural language focused. In the early phases, AI research in education places more emphasis on customizable learning systems, intelligent guidance systems, and data analysis in education. However, with the advent of ChatGPT and the advancement of large language models, the direction of research is now shifting to the use of generative AI in education, evaluation, and the creation of teaching materials. These changes show that advances in AI technology are significantly impacting the research path of science education. Generative AI is considered to be able to produce a more personalized, adaptive, and tailored learning experience to students' needs. This technology also opens new opportunities for teachers to create learning media and assessments.

e. Discussion

The findings show that AI research in science education continues to evolve and become a related and interdisciplinary field. This can be seen from the relationship of the 6 clusters identified above showing that the research themes cannot operate

independently but are related to each other by complementing or influencing each other. Strong relationships among keywords such as science education, students, education, and teaching show that AI implementation primarily focuses on improving learning processes, teaching practices, and learner engagement. Furthermore, the integration of themes related to educational technology, machine learning, computational approaches, and learning analytics reflects the increasing role of AI in supporting intelligent learning environments. These findings are in line with previous studies that showed that AI technology is increasingly integrated into the education system to improve learning effectiveness and improve the student experience (Zhu et al., 2024).

Additionally, emerging topics such as ChatGPT, large language models, and generative artificial intelligence show the transition from traditional AI applications to more adaptive and personalized learning systems. Previous studies have reported that generative AI has great potential to support personalized learning by tailoring teaching methods, learning materials, and learning pace according to individual needs of students (Kohnke et al., 2025). These developments show that AI technology is increasingly being used not only to automate the educational process but also to create a flexible and learner-centric educational experience. The development of AI in science education is shaping more adaptive, personalized and technology-based learning. In addition, it can also form well-regulated learning of students.

Other findings in this bibliometric show that AI can be integrated with several other fields such as computer science, data science and immersive technologies such as augmented reality and virtual reality. This development is getting better towards a multidisciplinary approach. In addition, another trend is the emergence of cluster language models that show that AI has switched from traditional systems to generative AI. The impact felt by learning can be more flexible and pose new challenges to implement information validation, ethics, dependency in the use and critique of what AI conveys (Salih et al., 2025).

Although research on AI in science education continues to increase, the results of the analysis still show that there are still some gaps. First, much of the research is still exploratory and therefore empirically limited. Second, generalizations are lacking because they exist in a particular region or research context. Third, research with long-term impacts such as creativity, critical thinking, and science literacy is still rare. Therefore, it is hoped that previous research can explore AI more by filling the gap above, especially in science education.

4. CONCLUSION

The bibliometric study mapping AI research in science education from 2018-2025 using scopus-indexed data. The findings obtained are that research related to AI in science education has undergone significant development, this can be seen from the keywords divided into 6 main clusters, namely (1) science education and teaching, (2) computing and education, (3) learning outcomes, (4) language models, (5) machine learning, and (6) emerging technologies. Visible visualization is the latest research trend shifting from traditional AI applications to generative AI that is more flexible to be used in learning. The impact obtained is to support student involvement in learning, efficient evaluation and learning that uses immersive technology. Overall, this study provides a comprehensive overview of the structure, trends and future direction of AI research in science education so that it can be used as a benchmark for future researchers.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

6. REFERENCES

- Akhmadiyeva, R. S., Udina, N. N., Kosheleva, Y. P., Zhdanov, S. P., Timofeeva, M. O., & Budkevich, R. L. (2023). Artificial intelligence in science education: A bibliometric review. *Contemporary Educational Technology*, 15(4), ep460. <https://doi.org/10.30935/cedtech/13587>
- Al Darayseh, A. (2023). Acceptance of artificial intelligence in teaching science: Science teachers' perspective. *Computers and Education: Artificial Intelligence*, 4, 100132. <https://doi.org/10.1016/j.caeai.2023.100132>
- AlKanaan, H. N. M. (2022). Awareness Regarding the Implication of Artificial Intelligence in Science Education among Pre-Service Science Teachers. *International Journal of Instruction*, 15(3), 895-912.
- Chen, L., Chen, P., & Lin, Z. (2020). Artificial intelligence in education: A review. *IEEE Access*, 8, 75264–75278.
- Cooper, G. Examining Science Education in ChatGPT: An Exploratory Study of Generative Artificial Intelligence. *J Sci Educ Technol* 32, 444–452 (2023). <https://doi.org/10.1007/s10956-023-10039-y>
- Dimitriadou, E. & Lanitis, A. (2023) A Critical Evaluation, Challenges, and Future Perspectives of Using Artificial Intelligence and Emerging Technologies in Smart Classrooms. *Smart Learning Environments*, 10, Article No. 12. <https://doi.org/10.1186/s40561-023-00231-3>
- FitzGerald, E., Ferguson, R., Adams, A., Gaved, M., Mor, Y., & Thomas, R. (2013). Augmented reality and mobile learning: The state of the art. *International Journal of Mobile and Blended Learning*, 5(4), 43-58. <https://doi.org/10.4018/ijmbl.2013100103>
- Holmes, W., & Tuomi, I. (2022). State of the art and practice in AI in education. *European Journal of Education*, 57, 542–570. <https://doi.org/10.1111/ejed.12533>
- Huang, X., & Qiao, C. (2022). Enhancing Computational Thinking Skills Through Artificial Intelligence Education at a STEAM High School. *Science & Education*. <https://doi.org/10.1007/s11191-022-00392-6>
- Jiang, W. (2025). Deep Learning-Based Prediction of Student Performance in Physics Education Using Multimodal Data. *Proceedings of the 2025 International Conference on Big Data and Informatization Education*, 119–124. <https://doi.org/10.1145/3729605.3729627>
- Kasman, R. A. (2025). The Utilisation Of Artificial Intelligence, Internet Of Things, And Virtual/Augmented Reality In Enhancing The Effectiveness and Efficiency Of Learning: A Literature Review. *Indonesian Journal of Education (INJOE)*, 4(3), 434-443.
- Kohnke, L., Zou, D., & Su, F. (2025). Exploring the potential of GenAI for personalised English teaching: Learners' experiences and perceptions. *Computers and Education: Artificial Intelligence*, 8, 100371.
- Lolinco, A. T. & Holme, T. A. (2024). Understanding Student Help-Seeking for Contextualizing Chemistry through Curated Chatbot Data Analysis. *Journal of*

- Chemical Education, 101 (11), 4837–4846.
<https://doi.org/10.1021/acs.jchemed.4c00766>
- Salih, S., Husain, O., Hamdan, M., Abdelsalam, S., Elshafie, H., & Motwakel, A. (2025). Transforming education with AI: A systematic review of ChatGPT's role in learning, academic practices, and institutional adoption. *Results in Engineering*, 25, 103837.
- Sri Rezeki Lumbantoruan, Renata Agustina Silalah, Theodora Lyas Pita, Hardina Emelia Sitepu, Farizka Khairani, Josafat Sijabat, ... Deo Demonta Panggabean. (2025). Transformasi Pendidikan Fisika Era Digital: Inovasi Teknologi AR, AI, dan Mixed Reality dalam Pembelajaran STEM. *Jurnal Sosial Humaniora Dan Pendidikan*, 4(2), 352–362. <https://doi.org/10.55606/inovasi.v4i2.4083>
- Mahroof, A., Gamage, V., Rajendran, K., Rajkumar, S., Rajapaksha, S., & Wijendra, D. (2020). An AI based chatbot to self-learn and self-assess performance in ordinary level chemistry. In *Proceedings of the 2nd International Conference on Advancements* <https://doi.org/10.1109/ICAC51239.2020.9357131>
- Wu, T. & Tegmark, M. (2019). Toward an AI Physicist for Unsupervised Learning. arXiv. <https://doi.org/10.48550/arXiv.1810.10525>
- Xu, W., Ouyang, F. The application of AI technologies in STEM education: a systematic review from 2011 to 2021. *IJ STEM Ed* 9, 59 (2022). <https://doi.org/10.1186/s40594-022-00377-5>
- Yilmaz, Ö. (2024). Personalised learning and artificial intelligence in science education: current state and future perspectives. *Educational Technology Quarterly* [Online], 2024(3), pp.255–274. Available from: <https://doi.org/10.55056/etq.744>
- Zhai, X., He, P., & Krajcik, J. (2022). Applying machine learning to automatically assess scientific models. *Journal of Research in Science Teaching*, 59(10), 1765-1794. <https://doi.org/10.1002/tea.21773>
- Zhu, Y., Zuo, H., & Chen, Y. (2024). Digital Transformation in Vocational Education: Challenges, Strategies, and an Experimental Proposal (pp. 643–650). Atlantis Press. https://doi.org/10.2991/978-94-6463-242-2_79
- Zawacki-Richter, O., Marín, V.I., Bond, M. et al. Systematic review of research on artificial intelligence applications in higher education – where are the educators?. *Int J Educ Technol High Educ* 16, 39 (2019). <https://doi.org/10.1186/s41239-019-0171-0>