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Tracing 21st-Century Trends of Computational Thinking in Educational Research in Indonesia

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ABSTRACT

This study aims to analyze the publication trends of computational thinking (CT) in the field of education in Indonesia using data from the Scopus database. Using a defined search strategy, a total of 72 documents published between 2018 and 2025 were retrieved and analyzed through bibliometric methods using R Program and VOSviewer. The analysis focuses on identifying research trends, conceptual focus, and keyword novelty related to CT in the Indonesian educational context. The results show a significant increase in research activity, particularly after 2021, with a notable publication peak in 2024. This upward trend reflects growing awareness among researchers and educators about the importance of integrating CT into 21st-century learning. Beyond theoretical perspectives, the studies include practical implementations such as game-based learning, augmented reality, artificial intelligence, educational robotics, and curriculum development. The bibliometric visualization highlights emerging keywords like “Artificial Intelligence” and “Problem Solving” as promising areas for future research. These keywords indicate an expanding research direction toward interdisciplinary approaches and technology-enhanced learning environments. The main contribution of this study lies in its focused bibliometric mapping of computational thinking research within the Indonesian educational landscape. Unlike previous studies that explore CT on a global or general scale, this research offers specific insights into national-level trends, current gaps, and thematic developments. The findings are expected to guide researchers, educators, and policymakers in designing relevant educational strategies and identifying underexplored areas for future investigation.

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1. Introduction

Education serves as the cornerstone for shaping individual character, skills, and perspectives needed to navigate life challenges [1]–[4]. Moral values, critical thinking skills, and the capabilities needed in the workforce and society are all acquired through education [5]–[7]. It encourages the growth of flexible, creative, and problem-solving mentalities [8], [9]. Additionally, education gives people the chance to reach their full potential in terms of their social, emotional, and intellectual capacities [10]–[12]. Given the tremendous advancements in technology and information in the

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twenty-first century, education needs to adapt to the changing needs of the times [13]. In order to educate students for global competitiveness, it is imperative that 21st century skills be incorporated into the educational process. One of these crucial skills is computational thinking.

Computational thinking skills are one of the essential skills needed to face the challenges of the 21st century, especially in the world of education and technology [14], [15]. Problem decomposition, pattern recognition, algorithmic reasoning, abstraction, and generalization are all components of computational thinking [16]. Because it promotes effective, critical, and systematic thinking, this skill is beneficial across a range of fields and is not just pertinent to individuals working in computer science. Computational thinking can foster creativity, problem-solving abilities, and an awareness of the constantly changing digital technology process in the classroom [17]–[19]. Using computational thinking in the classroom can also help students become more curious, persistent, and confident while solving challenging tasks [20], [21]. Therefore, the integration of computational thinking in the curriculum is a strategic step to equip the younger generation with relevant skills in the rapidly changing digital era.

The development of computational thinking in general has attracted researchers from various disciplines to explore its concepts, applications, and impacts in diverse contexts. This growing interest indicates that computational thinking is no longer limited to the field of computer science but has expanded into areas such as social sciences, economics, and industry. Fig. 1 shows a significant surge in the number of publications related to computational thinking over the past five years. This increase reflects the rising academic interest in the topic and the urgency to understand its broader implications. Therefore, it is important to map and analyze the research landscape of computational thinking, one of which can be done through a bibliometric approach.

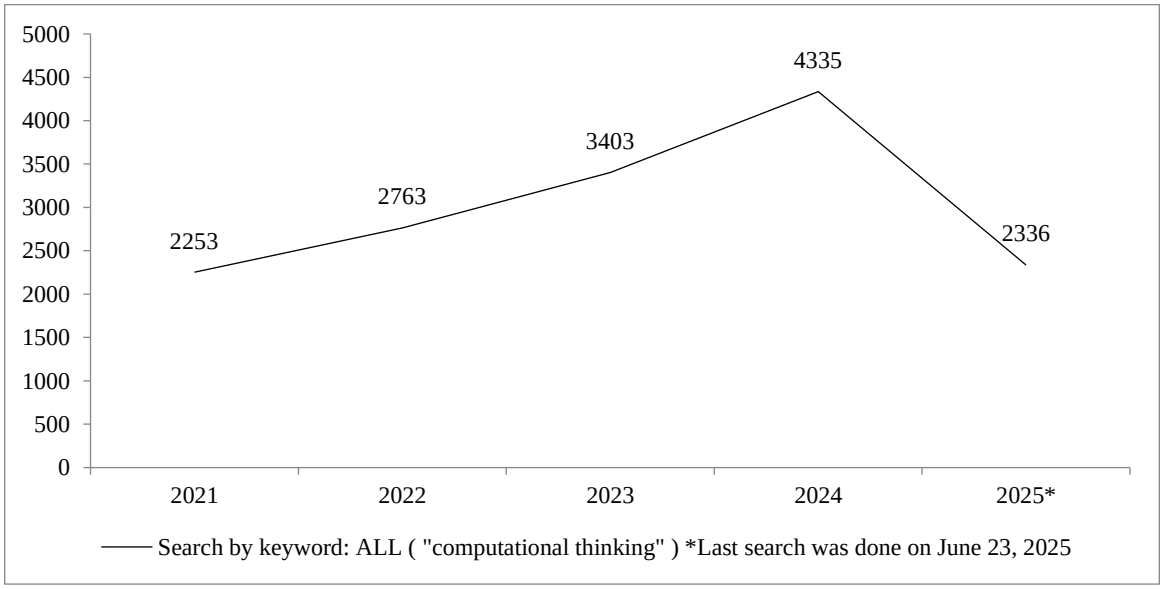

Fig. 1. Publication Trends Over the Last 5 Years with a Focus on Computational Thinking with a General Focus on the Scopus Database

This bibliometric analysis aims to explore and map the development of research on computational thinking specifically in the field of education. One of the results of previous publications shows that the research only discusses computational thinking in general and has not been directed specifically to the educational context [22]. In addition, the scope of the analysis is limited to publication trends up to 2021, which does not reflect the most recent dynamics in the field. Therefore, a more comprehensive and up-to-date study is needed to better understand the direction and focus of computational thinking research in education, particularly in Indonesia. This study makes two key contributions. First, it provides a bibliometric mapping of research in the Indonesian context, which is still limited in global literature. Second, it identifies thematic areas and emerging keywords that can guide future studies. Although focused on Indonesia, the findings offer insights for the global

academic community by showing how computational thinking is applied in developing countries to support 21st-century education.

2. Method

2.1. Research Design

This study adopts a bibliometric research design, which focuses on systematically analyzing academic publications to identify patterns, trends, and developments within a specific research domain [23]–[27]. The design is structured to explore the research focus and keyword novelty related to computational thinking in educational research. It involves the formulation of search strategies using predefined keywords, data retrieval from the Scopus database, and the application of inclusion and exclusion criteria to refine the dataset. The research design is limited to examining titles and metadata to ensure alignment with the study's objective. This approach enables a structured and replicable process for uncovering the conceptual focus and emerging terminologies within the selected body of literature.

2.2. Search Strategy

The image illustrates the flowchart of the document identification and selection process for the bibliometric analysis, following a PRISMA-based approach (Fig. 2). The study focuses on the topic "Computational Thinking in Educational Research in Indonesia," with data retrieved from the Scopus database covering the years 2018 to 2025. The search string included terms such as "computational thinking" along with "learn*," "school*," and "educat*." Data extraction was conducted on 27 June 2025, yielding a total of 1,625 documents with no duplicates. During the screening phase, documents were filtered by region, limiting the scope only to publications affiliated with Indonesia. This reduced the number of relevant documents to 72. In the eligibility stage, titles and abstracts were reviewed to ensure their alignment with the research topic, and no further documents were excluded. As a result, all 72 documents were included for the final bibliometric analysis. This flowchart reflects a systematic and targeted selection process to ensure regional focus and thematic relevance.

2.3. Inclusion and Exclusion Criteria

The inclusion and exclusion process in this study was conducted systematically to ensure that only relevant documents were analyzed. The inclusion criteria focused on documents that specifically discussed computational thinking within the context of education and were affiliated with institutions in Indonesia. The analysis included articles, conference papers, and reviews published between 2018 and 2025. Meanwhile, the exclusion criteria involved removing documents that were not related to educational settings, particularly those discussing computational thinking in medical or clinical contexts. This approach ensured that the selected publications aligned with the study's objective of exploring trends in computational thinking research within the Indonesian education sector.

2.4. Data Analyze

Data analysis in this study was carried out using two primary tools: R Program and VOSviewer. The R Program was utilized to extract the main information from the selected publications, such as the number of documents per year, types of documents, sources of publication, as well as the distribution of authors and affiliations. In addition, R was used to identify publication trends over time, providing insights into the development and growth of research on computational thinking in the field of education in Indonesia.

Meanwhile, VOSviewer was employed to analyze the research focus and keyword novelty within the dataset. This analysis involved mapping the relationships between frequently occurring keywords found in the titles and abstracts, as well as visualizing networks based on keyword co-occurrence. Through VOSviewer, key research themes and emerging terms could be identified, reflecting shifts and expansions in the direction of computational thinking research. This approach enabled a deeper understanding of the conceptual focus and evolving dynamics of the field.

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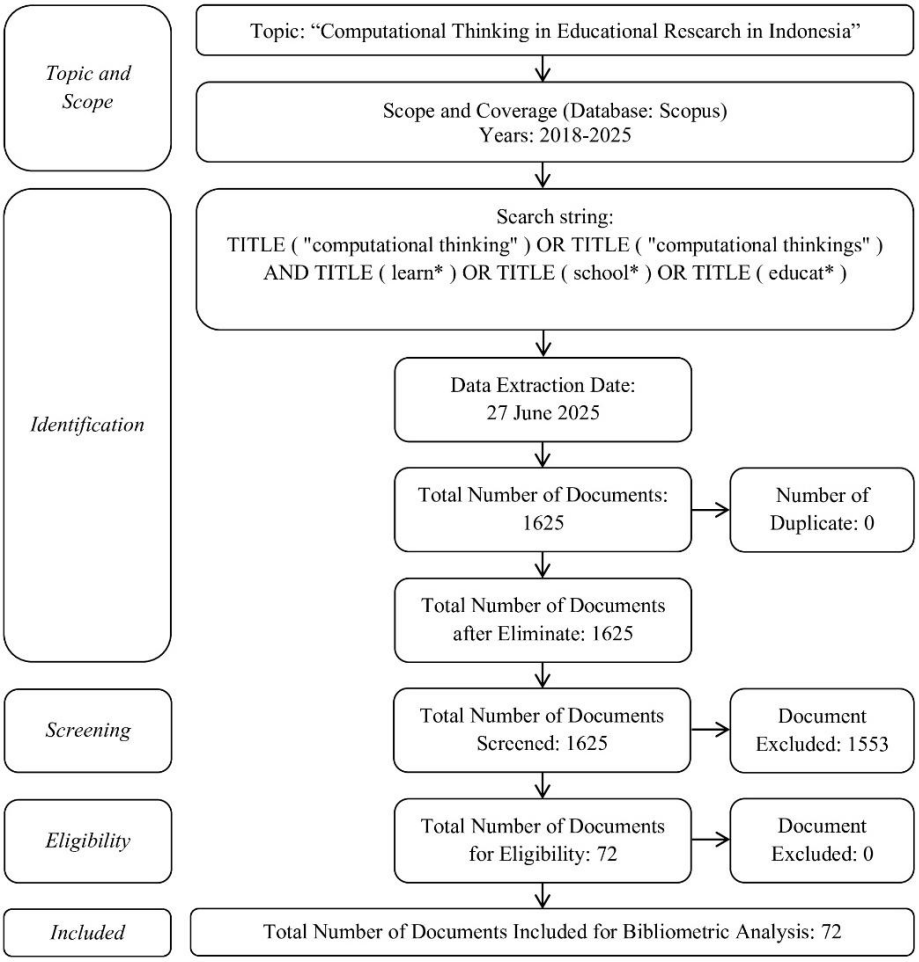

Fig. 2. PRISMA Method for Document Selection

3. Results and Discussion

3.1. Main Information

The main information analysis in the R Program aims to obtain an overview of the characteristics of the documents analyzed, such as the number of publications per year, types of documents, and sources of publication [28]. This information is the basis for understanding the trends and early developments of research related to computational thinking in the context of education in Indonesia.

The main information analysis (Fig. 3) of the 72 documents published between 2018 and 2025 shows an annual growth rate of 29.17%, indicating a rising interest in the topic of computational thinking in the context of education in Indonesia. These documents come from 40 different sources, including journals, conference proceedings, and other. The average document age is 2.03 years, suggesting that the topic remains relatively recent and actively researched. The average number of citations per document is 2.639, reflecting a growing academic attention, supported by a total of 2,975 references used across the dataset.

In terms of content, there are 157 author's keywords and 127 keywords plus, showing a wide range of research focuses and approaches. The dataset includes 280 authors, with only 2 single-authored documents, and an average of 4.33 co-authors per document, highlighting a strong trend of collaborative research. The international co-authorship rate is 27.78%, indicating some level of global collaboration, although most research remains locally driven. Regarding document types, journal articles (36) and conference papers (34) dominate, while review papers are limited to just 2, suggesting that empirical studies are more common than conceptual or literature-based reviews in this field.

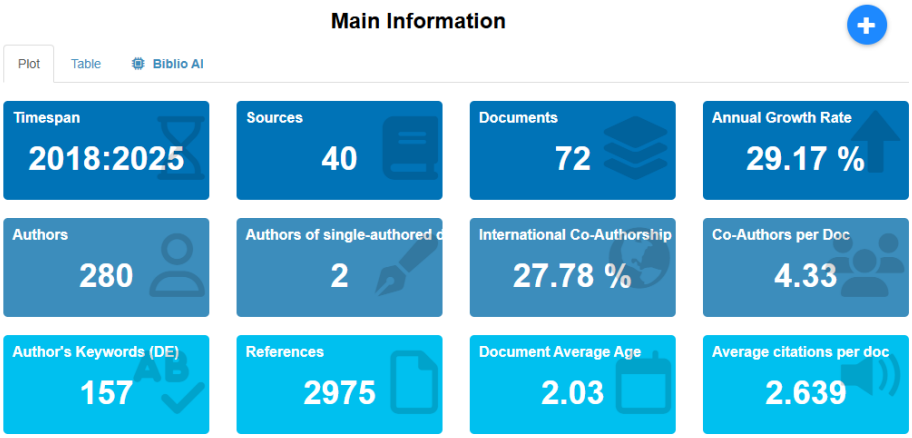

Fig. 3. Main Information

3.2. Publication Trends

The analysis of publication trends over the years aims to observe the development and growth of researchers' interest in the chosen topic [28]. This pattern helps identify periods of increase or decline in research activity, which can indicate the shifting dynamics of scientific focus over time.

The publication trend data from 2018 to 2025 shows a fluctuating but overall increasing pattern in the number of documents related to computational thinking in the context of education in Indonesia (Fig. 4). During the early years (2018–2021), the number of publications remained low and relatively stable, ranging from 2 to 5 documents per year. This suggests that computational thinking was still in its initial phase of recognition and had not yet become a central focus in educational research. However, a significant increase is observed starting in 2022 with 8 publications, followed by a sharp rise in 2024 with 30 documents, marking the highest number of publications in the entire period.

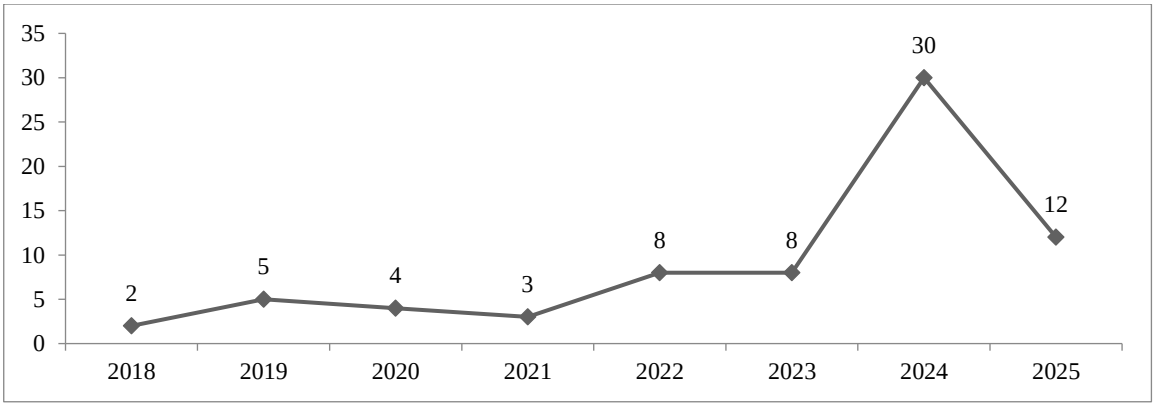

Fig. 4. Publication Trends From 2018 to 2025 (Data Analysis using R Program)

The dramatic surge in 2024 indicates a strong academic momentum and growing interest in computational thinking, possibly driven by educational needs or national and global policy shifts. Although the number of publications slightly declined to 12 in 2025, it remains considerably higher compared to the early years, showing sustained relevance of the topic. There is a significant upward trend in computational thinking research in Indonesian education, especially after 2021, with a peak in 2024. This reflects increasing awareness of the importance of integrating computational thinking into 21st-century education systems.

3.3. Focus Research

Focus research analysis on VOSviewer aims to identify the main themes that are the focus of attention in computational thinking research in education [28]. By mapping the relationships between keywords, this analysis helps to reveal the most dominant research directions, concentrations, and tendencies in the data set.

The bibliometric analysis reveals that computational thinking is the central focus of educational research in Indonesia, strongly connected to various innovative learning approaches (Fig. 5). This is evident from its association with keywords such as “game-based learning”, “augmented reality”, “engagement”, and “critical thinking”. These connections indicate a growing trend among researchers to integrate computational thinking into interactive and engaging learning environments that promote 21st-century skills. Another significant research focus centers on the development and application of technology in education. This is reflected in the connections between computational thinking and keywords like “educational robots”, “artificial intelligence”, and “learning media”. Such associations suggest that Indonesian researchers are not only exploring theoretical aspects but also emphasizing the practical implementation of advanced technologies to enhance students' computational thinking skills, particularly at the elementary level, as shown by the presence of keywords like “elementary school” and “learning models”.

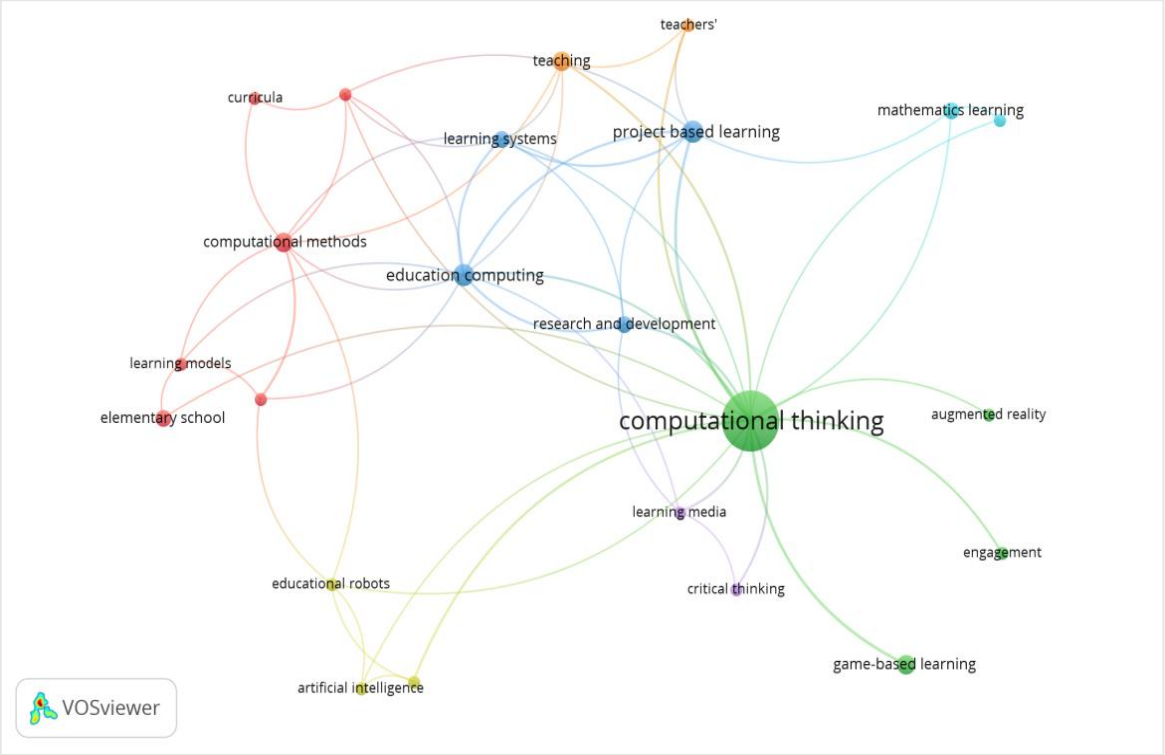

Fig. 5. Focus Research

Additionally, there is a thematic cluster highlighting the integration of computational thinking into formal curricula and learning systems. Keywords such as “curricula”, “teaching”, “project-based learning”, and “education computing” point to research focusing on how computational thinking can be embedded within project-based instruction and broader educational frameworks. This indicates an interest in curriculum development and teacher training as strategies to systematize the implementation of computational thinking in Indonesian education.

3.4. Keyword Novelty

Keyword novelty analysis aims to identify new keywords that are starting to emerge in the topic [28]. These findings provide an overview of the direction of current research development in Indonesia and show topics that are starting to receive attention from researchers (Fig. 6). Keywords highlighted in yellow in the VOSviewer visualization indicate that these topics are relatively new in the field of computational thinking research in education. The yellow color reflects emerging keywords that have only appeared in recent years and have not yet been extensively studied. Therefore, these keywords are recommended for future research, as they represent current trends and open opportunities, particularly within the context of education in Indonesia.

One of the emerging keywords is “artificial intelligence”. The appearance of this term suggests a growing intersection between computational thinking and artificial intelligence in educational contexts. This integration has the potential to support the development of more adaptive, personalized, and data-driven learning strategies. By focusing on artificial intelligence, researchers can explore how intelligent technologies enhance computational thinking and contribute to innovative teaching and learning approaches in the digital age.

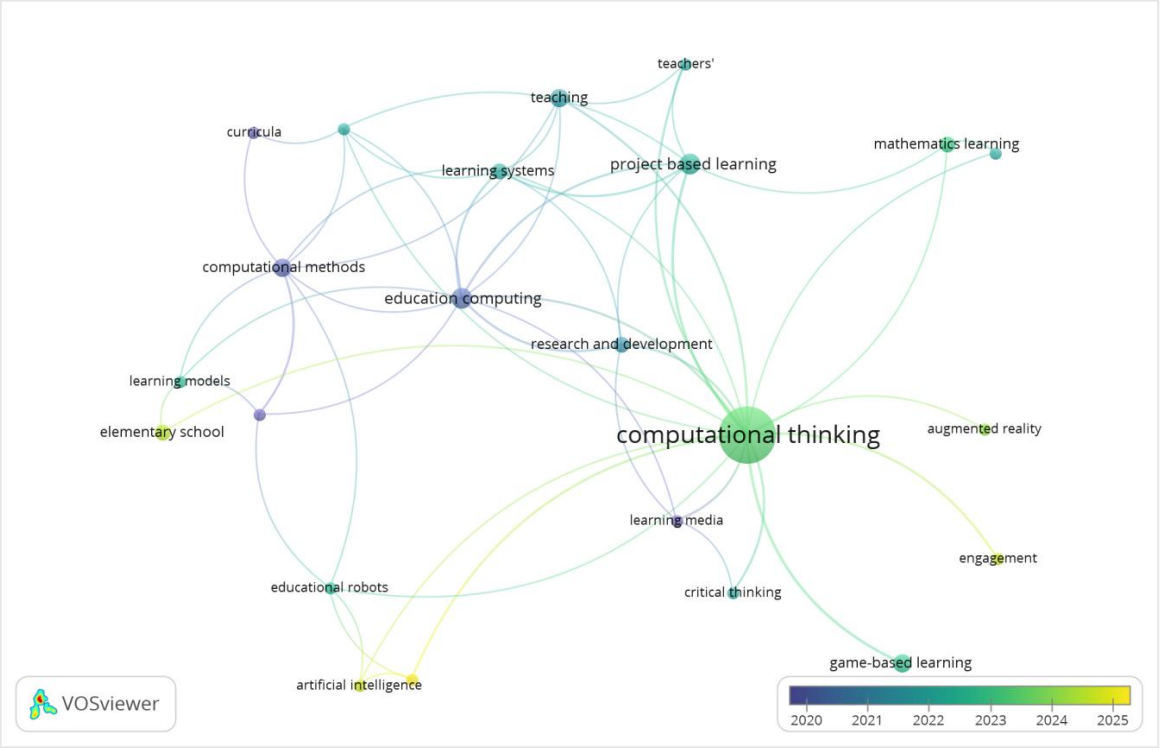

Fig. 6. Keywords Novelty

Another important emerging keyword is “problem solving”, which demonstrates a strong link between computational thinking and students' ability to solve complex problems. This term aligns with the broader aim of understanding how computational thinking supports analytical, strategic, and efficient thinking in addressing educational challenges. In conclusion, the presence of keywords such as “artificial intelligence” and “problem solving” highlights promising directions for future research on computational thinking in education.

4. Conclusion

The results show a significant increase in research activity, particularly after 2021, with a notable publication peak in 2024. This upward trend reflects growing awareness among researchers and educators about the importance of integrating CT into 21st-century learning. Beyond theoretical perspectives, the studies include practical implementations such as game-based learning, augmented reality, artificial intelligence, educational robotics, and curriculum development. The bibliometric visualization highlights emerging keywords like “Artificial Intelligence” and “Problem Solving” as promising areas for future research. These keywords indicate an expanding research direction toward interdisciplinary approaches and technology-enhanced learning environments. The main contribution of this study lies in its focused bibliometric mapping of computational thinking research within the Indonesian educational landscape. Unlike previous studies that explore CT on a global or general scale, this research offers specific insights into national-level trends, current gaps, and thematic developments. The findings are expected to guide researchers, educators, and policymakers in designing relevant educational strategies and identifying underexplored areas for future investigation.

Declaration

Supplementary Materials: The supplementary materials of this study include the complete dataset retrieved from Scopus and the visualizations generated using R Program and VOSviewer.

Author Contribution: Z: Conceptualization, Writing - Original Draft, Editing and Visualization; MLBG: Methodology and Review & Editing; ADO: Conceptualization, Formal analysis, Methodology and Review & Editing; LA: Validation and Supervision. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declare no conflict of interest.

References

[1] Y. Xu, H. Yu, X. Wan, and L. Zhang, "Strategies for sustainable development in university education: Breaking barriers and cultivating awareness," *Educ. Inf. Technol.*, vol. 29, no. 17, pp. 22567–22608, 2024, https://doi.org/10.1007/s10639-024-12727-7.

[2] S. Ø. Nissen, "Forces of responsible leadership: A multiple case study on enhancing sustainable inner development through management education," *Int. J. Manag. Educ.*, vol. 23, no. 3, p. 101224, 2025, https://doi.org/10.1016/j.ijme.2025.101224.

[3] A. Alam and A. Mohanty, "Integrated constructive robotics in education (ICRE) model: a paradigmatic framework for transformative learning in educational ecosystem," *Cogent Educ.*, vol. 11, no. 1, p. 2324487, Dec. 2024, https://doi.org/10.1080/2331186X.2024.2324487.

[4] S. M. Ghouse, D. Barber III, and K. Alipour, "Shaping the future Entrepreneurs: Influence of human capital and self-efficacy on entrepreneurial intentions of rural students," *Int. J. Manag. Educ.*, vol. 22, no. 3, p. 101035, 2024, https://doi.org/10.1016/j.ijme.2024.101035.

[5] G. Cruz, R. Payan-Carreira, C. Dominguez, H. Silva, and F. Morais, "What critical thinking skills and dispositions do new graduates need for professional life? Views from Portuguese employers in different fields," *High. Educ. Res. Dev.*, vol. 40, no. 4, pp. 721–737, 2021, https://doi.org/10.1080/07294360.2020.1785401.

[6] S. Yue, J. Wei, H. Aziz, and K. Liew, "A study on the effectiveness of self-assessment learning system of ideological and political education for college students," *Learn. Motiv.*, vol. 84, p. 101929, 2023, https://doi.org/10.1016/j.lmot.2023.101929.

[7] A. Khalil, N. Hellalet, and B. Outamgharte, "Investigating Moroccan EFL teachers' critical thinking attitudes: The impact of teaching experience and gender," *Think. Ski. Creat.*, vol. 56, p. 101746, 2025, https://doi.org/10.1016/j.tsc.2024.101746.

[8] P. Ellerton and R. Kelly, "Creativity and critical thinking," in *Education in the 21st century: STEM, creativity and critical thinking*, Springer, 2022, pp. 9–27, https://doi.org/10.1007/978-3-030-85300-6_2.

[9] H. Fuchs, E. Benkova, A. Fishbein, and A. Fuchs, "The importance of psychological and cognitive flexibility in educational processes to prepare and acquire the skills required in the Twenty-First century," in *The Global Conference on Entrepreneurship and the Economy in an Era of Uncertainty*, 2023, pp. 91–114, https://doi.org/10.1007/978-981-97-0996-0_6.

[10] M. Estrada, D. Monferrer, A. Rodriguez, and M. Á. Moliner, "Does emotional intelligence influence academic performance? The role of compassion and engagement in education for sustainable development," *Sustainability*, vol. 13, no. 4, p. 1721, 2021, https://doi.org/10.3390/su13041721.

[11] L. Markauskaite, R. Marrone, O. Poquet, S. Knight, R. Martinez-Maldonado, S. Howard, J. Tondeur, M. De Laat, S.B. Shum, D. Gašević, and G. Siemens, "Rethinking the entwinement between artificial intelligence and human learning: What capabilities do learners need for a world with AI?," *Comput. Educ. Artif. Intell.*, vol. 3, p. 100056, 2022, https://doi.org/10.1016/j.caeai.2022.100056.

[12] P. Gupta, R. Mahajan, U. Badhera, and P. S. Kushwaha, "Integrating generative AI in management education: A mixed-methods study using social construction of technology theory," *Int. J. Manag. Educ.*, vol. 22, no. 3, p. 101017, 2024, https://doi.org/10.1016/j.ijme.2024.101017.

[13] S. H. Khahro and Y. Javed, "Key challenges in 21st century learning: a way forward towards sustainable higher educational institutions," *Sustainability*, vol. 14, no. 23, p. 16080, 2022, https://doi.org/10.3390/su142316080.

[14] B. Alfaro-Ponce, A. Patiño, and J. Sanabria-Z, "Components of computational thinking in citizen science games and its contribution to reasoning for complexity through digital game-based learning: A framework proposal," *Cogent Educ.*, vol. 10, no. 1, p. 2191751, 2023, https://doi.org/10.1080/2331186X.2023.2191751.

[15] K. A. Mills, J. Cope, L. Scholes, and L. Rowe, "Coding and computational thinking across the curriculum: A review of educational outcomes," *Rev. Educ. Res.*, vol. 95, no. 3, pp. 581–618, 2025, https://doi.org/10.3102/00346543241241327.

[16] Y. A. Rodríguez del Rey, I. N. Cawanga Cambinda, C. Deco, C. Bender, R. Avello-Martínez, and K. O. Villalba-Condori, "Developing computational thinking with a module of solved problems," *Comput. Appl. Eng. Educ.*, vol. 29, no. 3, pp. 506–516, 2021, https://doi.org/10.1002/cae.22214.

[17] M. Paf and B. Dincer, "A Study of the Relationship between Secondary School Students' Computational Thinking Skills and Creative Problem-Solving Skills.," *Turkish Online J. Educ. Technol.*, vol. 20, no. 4, pp. 1–15, 2021, https://tojet.net/articles/v20i4/2041.pdf.

[18] H. Aksakal and S. Kucuk, "Secondary school students' computational thinking skills, group cohesion, and performance in problem-based programming education," *J. Syst. Softw.*, vol. 230, p. 112535, 2025, https://doi.org/10.1016/j.jss.2025.112535.

[19] O. Broza, L. Biberman-Shalev, and N. Chamo, "'Start from scratch': Integrating computational thinking skills in teacher education program," *Think. Ski. Creat.*, vol. 48, p. 101285, 2023, https://doi.org/10.1016/j.tsc.2023.101285.

[20] P. J. Rich, S. L. Mason, and J. O'Leary, "Measuring the effect of continuous professional development on elementary teachers' self-efficacy to teach coding and computational thinking," *Comput. Educ.*, vol. 168, p. 104196, 2021, https://doi.org/10.1016/j.compedu.2021.104196.

[21] Y.-P. Cheng, C.-F. Lai, Y.-T. Chen, W.-S. Wang, Y.-M. Huang, and T.-T. Wu, "Enhancing student's computational thinking skills with student-generated questions strategy in a game-based learning platform," *Comput. Educ.*, vol. 200, p. 104794, 2023, https://doi.org/10.1016/j.compedu.2023.104794.

[22] H. E. Chen, D. Sun, T.-C. Hsu, Y. Yang, and J. Sun, "Visualising trends in computational thinking research from 2012 to 2021: A bibliometric analysis," *Think. Ski. Creat.*, vol. 47, p. 101224, 2023, https://doi.org/10.1016/j.tsc.2022.101224.

[23] V. K. Singh, P. Singh, M. Karmakar, J. Leta, and P. Mayr, "The journal coverage of Web of Science, Scopus and Dimensions: A comparative analysis," *Scientometrics*, vol. 126, no. 6, pp. 5113–5142, 2021, https://doi.org/10.1007/s11192-021-03948-5.

[24] M. Tekdal, "Trends and development in research on computational thinking," *Educ. Inf. Technol.*, vol. 26, no. 5, pp. 6499–6529, 2021, https://doi.org/10.1007/s10639-021-10617-w.

[25] 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, no. 3, pp. 285–296, 2021, https://doi.org/10.1016/j.jbusres.2021.04.070.

[26] M.-C. Chiu, G.-J. Hwang, and Y.-F. Tu, "Roles, applications, and research designs of robots in science education: a systematic review and bibliometric analysis of journal publications from 1996 to 2020," *Interact. Learn. Environ.*, vol. 32, no. 5, pp. 1834–1859, May 2024, https://doi.org/10.1080/10494820.2022.2129392.

[27] N. Mishra, T. Bharti, A. K. Tiwari, and G. Pfajfar, "Public and scholarly interest in social robots: An investigation through Google Trends, bibliometric analysis, and systematic literature review," *Technol. Forecast. Soc. Change*, vol. 206, p. 123578, 2024, https://doi.org/10.1016/j.techfore.2024.123578.

[28] H. Retnawati and R. Hidayat, "Research Trends in Scopus Database on Technological Innovation in the Process of Mathematics Learning: A Bibliometric Analysis," *Int. J. Cogn. Res. Sci. Eng. Educ.*, vol. 13, no. 1, pp. 97–116, 2025, https://doi.org/10.23947/2334-8496-2025-13-1-97-116.