Computational Thinking and its Application in School: A Bibliometric Analysis (2008-2023)

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Abstract. The important role of Computational Thinking in the learning process has encouraged many studies that use this concept as a key variable. The aim of this research is to analyze publication trends as well as the novelty of keywords related to Computational Thinking. Using software such as RStudio and VOSviewer, analysis was carried out on 243 documents collected from Scopus based on relevant keywords. From the analysis results, it can be concluded that there were only 31 articles published on the topic of Computational Thinking in Schools between 2008 and 2016, but that number more than sevenfold increased to 209 publications between 2017 and 2022. Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) (SJR 2022 = 0.32) is the source with the highest h-index. English (2017) research on STEM education in elementary and middle schools is the most influential based on number of citations. From the results interpreted with VOSviewer, there are seven color clusters for Computational Thinking research with various research focuses. By looking at the overlay visualization, research on early childhood education has not directly involved other variables such as integration, systematic review, motivation, and relationships. Thus, this is a gap that can enable researchers in this field to carry out further research.

Keywords: Bibliometrics, Computational thinking, Schools.

1 Introduction

Rapid advances in technology and science have rapidly changed lifestyles and the global order, including in the context of education [1]–[4]. One of the professional skills that is very important in the 21st century, especially in the educational context, is Computational Thinking (CT) [5]–[7]. CT-based education helps students develop problem-solving, data analysis, modeling, and algorithmic thinking skills, thereby helping them solve complex problems, design systems, and understand human behavior based on computer science [8]–[10].

Computational thinking is part of the process that includes abstracting, describing, algorithmic thinking, evaluating, and generalizing [11]. This is needed in school learning because of its contribution in developing students' abilities to understand and solve complex problems, as well as helping them face the demands of increasingly rapid technological developments in the modern era. Thus, the importance of Computational Thinking is because now it has become a part that must be

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implemented in schools, this is due to the increasingly important role of computational thinking in preparing students to face challenges in the era of information technology that continues to develop [12].

In education, the application of Computational Thinking (CT) is very dependent on the role of teachers as educators who have an important role in integrating CT into the learning process, with the possibility to collaborate with fellow teachers who have expertise in CT [13], [14]. Thus, CT is very important because of its significant contribution in preparing students to face the challenges of information technology which continues to develop in the modern era. Research in the field of Computational Thinking (CT) in schools is developing very quickly. The growth of research in the field of engineering can be followed by a type of analysis known as bibliometric analysis. This analysis can be used to identify the number of scientific publications about CT.

Research on Computational Thinking has developed significantly in the school environment, and has become an important variable in many studies. To understand the novelties and emerging trends in this field, the researcher plans to conduct a bibliometric analysis using two main tools: Biblioshiny and VOSviewer. These tools will be used to explore and visualize scientific publication data in depth, so as to identify patterns, collaborative relationships, and emerging topics frequently researched in the academic literature on Computational Thinking.

2 Method

This bibliometric research was carried out with the aim of evaluating previous academic work that has been carried out in the context of using Computational Thinking in Schools Research. The first step in this research is to compile a complete list of publications that have the potential to become research samples [15]. This research is quantitative and descriptive, with a focus on the development of Computational Thinking in schools as well as publication distribution patterns in Scopus based on research affiliation, research themes and scientific journals [16]. For data analysis, reduction, visualization and mapping, the Bibliometrix R and BiblioShiny tools were used, as well as VOSviewer via R-Studio for overall article mapping [17].

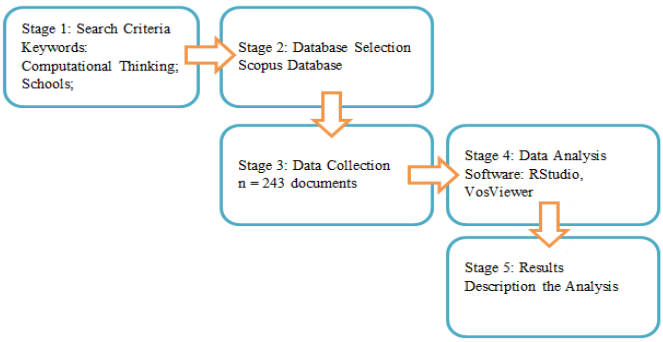

Fig. 1. Stage of bibliometrics about computational thinking in schools

This research emphasizes the importance of scientific resources related to Computational Thinking in schools. The use of the keywords "Computational Thinking" and "School" helps ensure the relevance and focus of the research. Through a search in the Scopus database, 243 relevant documents were obtained. Document evaluation was done to ensure suitability to the topic, using the Bibliometrix R-package and the Biblioshiny interface for bibliometric analysis that does not require programming skills, and VOSviewer for group and keyword mapping. The analysis results are then presented in detail and visually, with emphasis on the main findings and quantitative assessments related to the development of Computational Thinking in the school environment.

Findings and Discussions

.1 Findings [3]

Main Information. Table 1 displays the main information from Scopus, including number of entries, time period from 2008 to 12 September 2023, 65 sources (journals, books, etc.), documents (243), number of authors (579) found in Computational Thinking in Schools, and complete information can be seen in Table 1.

Table 1. Main information

Main Information about Data		Document Types	
Timespan	2008-2023	Article	51
Sources [s]	65	Book chapter	6
Documents	243	Conference paper	153
Annual growth rate %	16.97	Conference review	31
Document average age	3.67	Editorial	1
Average citations per doc	5.523	Retracted	1
References	5376		

ource: RStudio

Publication Trends. These resources growth rate is divided by annual occurrence in Table 2.

Table 2. Annual scientific production about computational thinking in school's research

Year	Articles	Year	Articles
2008	2	2016	9
2009	2	2017	13
2010	2	2018	24
2011	4	2019	38
2012	1	2020	30
2013	6	2021	42
2014	2	2022	41
2015	4	2023	21

Source: RStudio

There were only 31 articles published on the topic of Computational Thinking in Schools between 2008 and 2016, but that number more than sevenfold increased to 209 publications between 2017 and 2022. When compared with the total of 38 articles published in 2019, the number of publications decreased to only 24 articles in 2018. According to the review, the number of articles published in the field of Computational Thinking in Schools reached its peak in 2021 with 42 articles.

Most Productive Source. The main sources of research on Computational Thinking in Schools that have had the greatest impact are described in Table 3, which orders the sources based on the number of documents related to Computational Thinking in Schools that they cite. Using the most comprehensive and extensive bibliographic database for the last three years, SJR calculates the prestige or influence of scientific journals. The citation window used is wide enough to cover all journals in the database and dynamic so that it can track the development of scientific journals. In terms of overall number of documents, the top five sources are as follows: Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) (SJR 2022 = 0.32), Eurasia Journal Of Mathematics, Science and Technology Education (SJR 2022 = 0.51), Communications in Computer and Information Science (SJR 2022 = 0.19), ACM International Conference Proceedings Series (SJR 2021 = 0.23), and Mathematical Thinking and Learning (SJR 2022 = 0.93).

Table 3. Top 5 Resources based on impact in computational thinking in schools research

Source	h index
Lecture notes in computer science (including subseries lecture notes in artificial intelligence and lecture notes in bioinformatics)	13
Technology, knowledge, and learning	6
Eurasia Journal of Mathematics, Science and Technology Education	4
Communications in computer and information science	3
Mathematical thinking and learning	2

Source: RStudio

Highest Citation Publications. Table 4 shows the importance of Computational Thinking in education by highlighting key works in this field.

Table 4. Authors have had the greatest impact on computational thinking in schools research

Authors	Title	Total Citations
[18]	Advancing elementary and middle school STEM education	167
[19]	The effects of using different tools in programming teaching of secondary school students on engagement, computational thinking…	64
[20]	Educational robotics for inclusive education	57
[21]	It's computational thinking! Bebras tasks in the curriculum	52
[22]	Cultivating computational thinking practices…	43

Source: RStudio

English's (2017) research on STEM education in elementary and middle schools is the most influential based on number of citations [18]. Other works cover aspects such as the use of tools in teaching programming [19], educational robotics [20], the integration of Bebras tasks [21], and the practice of developing computational thinking [22]. The total citations represent the increasing contribution and interest in including Computational Thinking in school curricula.

Research Focus and Keywords Novelty. From the results interpreted with VOSviewer, there are seven color clusters for Computational Thinking research, with red as the largest cluster consisting of 11 keywords, with Computational Thinking and Primary School as the largest circle, indicating that red is the first research focus. The purple color is the second color by bringing up four keywords, with the largest circles being the words Environment and Science, which indicate the second research focus. Green is the third color with four keywords, with Computational and Research being the largest circle, with this being the third research focus. Yellow is the fourth color with five keywords, with the largest circle being the words School and Mathematics, with the fourth research focus. Blue with six keywords, with the words with the largest circles, namely Teacher and Curriculum, being the fifth research focus, so that the five research focuses above can be used as guidelines for conducting further research.

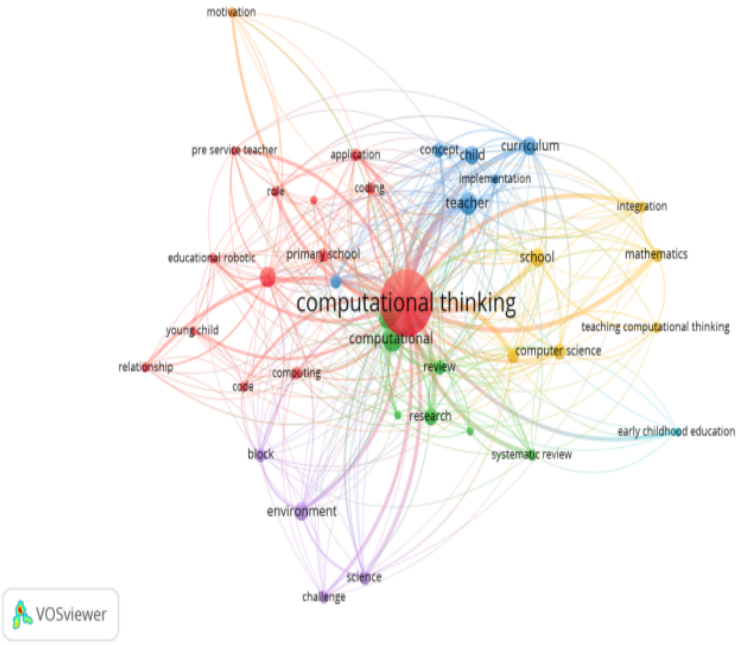

Fig. 2. Co-occurrence of keywords

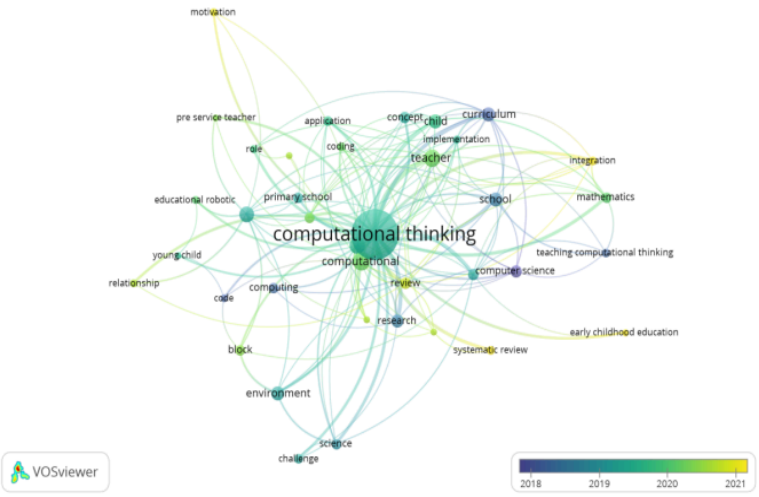

Fig. 3. Overlay visualization

In Figure 3, data on the co-occurrence of author keywords is displayed with overlay visualization. The yellow color represents the latest publications, meaning that the words systematic review, early childhood education, integration, motivation, review, and relationship are keywords that were only published around 2021. Research on early childhood education does not directly involve other variables such as integration, systematic review, motivation, and relationships. So, this is a gap that can enable researchers in this field to carry out further research.

3.2 **Discussion**

This research discusses publications related to Computational Thinking in Schools taken from the Scopus database which will be analyzed using RStudio and VOSviewer by looking at research development trends each year, authors who have the greatest impact, source documents that have the greatest impact, topics are related, emergence shared keywords, and collaboration between countries.

Regarding research development trends per year, 31 articles have been published on the topic of Computational Thinking in Schools between 2008 and 2016, but this number has more than sevenfold increased to 209 publications between 2017 and 2022. When compared with a total of 38 articles published in 2019, the number of publications decreased to only 24 articles in 2018. According to the review, the

number of articles published in the field of Computational Thinking in Schools reached its peak in 2021 with 42 articles.

The results of the analysis highlight the importance of Computational Thinking in education, with key works influencing various aspects. English (2017) highlighted STEM education at the primary and secondary school levels, being the most impactful research with a significant number of citations [18]. Other works address the use of tools in teaching programming [19] educational robotics [20] Bebras task integration [21] as well as the development of computational thinking practices [22]. Increasing citations indicate strong interest in the inclusion of Computational Thinking in school curricula. Leading scientific journals, such as Lecture Notes in Computer Science, Eurasia Journal of Mathematics, Science and Technology Education, Communications in Computer and Information Science, ACM International Conference Proceedings Series, and Mathematical Thinking and Learning, show the influence of research on Computational Thinking in recent years.

Regarding the appearance of keywords, there are seven color clusters, namely red with Computational Thinking and Primary School as the largest circle, purple is the second color with 4 keywords appearing, with the largest circle being the words Environment and Science, green is the color third with Computational and Research being the largest circle, yellow being the fourth color with five keywords, with the largest circle being the words School and Mathematics, blue with six keywords, with the words with the largest circle being Teacher and Curriculum being the fifth research focus. So that the five research focuses above can be used as guidelines for conducting further research. By looking at the overlay visualization, research on early childhood education has not directly involved other variables such as integration, systematic review, motivation, and relationships. So, this is a gap that can enable researchers in this field to carry out further research.

4 Conclusion

From the analysis results, it can be concluded that there were only 31 articles published on the topic of Computational Thinking in Schools between 2008 and 2016, but that number more than sevenfold increased to 209 publications between 2017 and 2022. Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) (SJR 2022 = 0.32) is the source with the highest h-index. [18] research on STEM education in elementary and middle schools is the most influential based on number of citations. From the results interpreted with VOSviewer, there are seven color clusters for Computational Thinking research with various research focuses. By looking at the overlay visualization, research on early childhood education has not directly involved other variables such as integration, systematic review, motivation, and relationships. So, this is a gap that can enable researchers in this field to carry out further research.

References

1. Z. Zetriuslita, R. Ariawan, and H. Nufus, “Analisis kemampuan berpikir kritis matematis mahasiswa dalam menyelesaikan soal uraian kalkulus integral berdasarkan level

kemampuan mahasiswa," *Infin. J.*, vol. 5, no. 1, pp. 56–65, Feb. 2016, doi: 10.22460/infinity.v5i1.p56-66.
2. Z. Zafrullah, S. Suyanto, A. Wahyuni, R. T. Ayuni, and F. R. E. Novilanti, "Development of Android-based learning to improve computational thinking skills in junior high school," *J. Cendekia J. Pendidik. Mat.*, vol. 7, no. 2, pp. 1309–1320, May 2023, doi: 10.31004/cendekia.v7i2.2239.
3. Z. Zetriuslita, N. Nofriyandi, and E. Istikomah, "The increasing self-efficacy and self-regulated through GeoGebra based teaching reviewed from Initial Mathematical ability (IMA) level," *Int. J. Instr.*, vol. 14, no. 1, pp. 587–598, Jan. 2021, doi: 10.29333/iji.2021.14135a.
4. Z. Zafrullah and Z. Zetriuslita, "Learning interest of seventh grade students towards mathematics learning media assisted by Adobe Flash CS6," *Math Didact. J. Pendidik. Mat.*, vol. 7, no. 2, pp. 114–123, Aug. 2021, doi: 10.33654/math.v7i2.1272.
5. R. R. P. Ria, "Asesmen computational thinking di pendidikan matematika: Analisis bibliometrik menggunakan Vosviewer," *EDUPEDIKA J. Stud. Pendidik. dan Pembelajaran*, vol. 2, no. 2, pp. 27–38, 2023, [Online]. Available: https://journal.pelitanusa.or.id/index.php/edupedika/article/view/66.
6. D. Andrian, A. Wahyuni, S. Ramadhan, F. R. E. Novilanti, and Z. Zafrullah, "Pengaruh pembelajaran kooperatif tipe STAD terhadap peningkatan hasil belajar, sikap sosial, dan motivasi belajar," *INOMATIKA*, vol. 2, no. 1, pp. 65–75, Jan. 2020, doi: 10.35438/inomatika.v2i1.163.
7. M. Yunus, M. Abrory, Z. Zafrullah, D. Andrian, and D. Maclinton, "The effectiveness of Macromedia Flash digital media in improving students' mathematics reasoning," *Math. Res. Educ. J.*, vol. 6, no. 1, pp. 14–20, Feb. 2022, doi: 10.25299/mrej.2022.vol6(1).9013.
8. X. Wei, L. Lin, N. Meng, W. Tan, S.-C. Kong, and Kinshuk, "The effectiveness of partial pair programming on elementary school students' computational thinking skills and self-efficacy," *Comput. Educ.*, vol. 160, p. 104023, Jan. 2021, doi: 10.1016/j.compedu.2020.104023.
9. A. Fitriani, R. Rosidah, and Z. Zafrullah, "Biblioshiny: Implementation of artificial intelligence in education (1976-2023)," *J. Technol. Glob.*, vol. 1, no. 1, pp. 11–25, 2023, [Online]. Available: https://penaeducentre.com/index.php/JTeG/article/view/40.
10. Z. Zafrullah *et al.*, "Item response theory in education: A biblioshiny analysis (1987-2023)," *J. Educ. Glob.*, vol. 1, no. 1, pp. 101–114, 2023, [Online]. Available: https://penaeducentre.com/index.php/JEdG/article/view/30.
11. M. Kallia, S. P. van Borkulo, P. Drijvers, E. Barendsen, and J. Tolboom, "Characterising computational thinking in mathematics education: A literature-informed Delphi study," *Res. Math. Educ.*, vol. 23, no. 2, pp. 159–187, May 2021, doi: 10.1080/14794802.2020.1852104.
12. A. T. Megawati, M. Sholihah, and K. Limiansih, "Implementasi computational thinking dalam pembelajaran matematika di sekolah dasar," *J. Rev. Pendidik. Dasar J. Kaji. Pendidik. dan Has. Penelit.*, vol. 9, no. 2, pp. 96–103, May 2023, doi: 10.26740/jrpd.v9n2.p96-103.
13. Z. Zafrullah, M. L. Hakim, and M. Angga, "ChatGPT open AI: Analysis of mathematics education students learning interest," *J. Technol. Glob.*, vol. 1, no. 1, pp. 1–10, 2023, [Online]. Available: https://penaeducentre.com/index.php/JTeG/article/view/35.
14. E. Tucker-Raymond, M. Cassidy, and G. Puttick, "Science teachers can teach computational thinking through distributed expertise," *Comput. Educ.*, vol. 173, p. 104284, Nov. 2021, doi: 10.1016/j.compedu.2021.104284.
15. M. H. Oermann *et al.*, "Information sources for developing the nursing literature," *Int. J. Nurs. Stud.*, vol. 45, no. 4, pp. 580–587, Apr. 2008, doi: 10.1016/j.ijnurstu.2006.10.005.

16. M. Aria and C. Cuccurullo, “Bibliometrix : An R-tool for comprehensive science mapping analysis,” *J. Informetr.*, vol. 11, no. 4, pp. 959–975, Nov. 2017, doi: 10.1016/j.joi.2017.08.007.
17. C. Cuccurullo, M. Aria, and F. Sarto, “Foundations and trends in performance management. A twenty-five years bibliometric analysis in business and public administration domains,” *Scientometrics*, vol. 108, no. 2, pp. 595–611, Aug. 2016, doi: 10.1007/s11192-016-1948-8.
18. L. D. English, “Advancing elementary and middle school STEM education,” *Int. J. Sci. Math. Educ.*, vol. 15, no. S1, pp. 5–24, May 2017, doi: 10.1007/s10763-017-9802-x.
19. H. Y. Durak, “The effects of using different tools in programming teaching of secondary school students on engagement, computational thinking and reflective thinking skills for problem solving,” *Technol. Knowl. Learn.*, vol. 25, no. 1, pp. 179–195, Mar. 2020, doi: 10.1007/s10758-018-9391-y.
20. L. Daniela and M. D. Lytras, “Educational robotics for inclusive education,” *Technol. Knowl. Learn.*, vol. 24, no. 2, pp. 219–225, Jun. 2019, doi: 10.1007/s10758-018-9397-5.
21. V. Dagienė and S. Sentance, “It’s computational thinking! Bebras tasks in the curriculum,” in International Conference on Informatics in Schools: Situation, Evolution, and Perspectives: 9th International Conference on Informatics in Schools: Situation, Evolution, and Perspectives, ISSEP 2016 Münster, Germany, October 13-16, 2016, Proceedings, A. Brodnik and F. Tort, Eds. Springer, 2016, pp. 28–39.
22. C. (Yu) Pei, D. Weintrop, and U. Wilensky, “Cultivating computational thinking practices and mathematical habits of mind in lattice land,” *Math. Think. Learn.*, vol. 20, no. 1, pp. 75–89, Jan. 2018, doi: 10.1080/10986065.2018.1403543.