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Trends of Primary School Teachers Computational Thinking Research: Bibliometric Analysis

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Abstract
The growing emphasis on Computational Thinking (CT) skills among elementary school teachers highlights its importance in improving learning quality in the digital era. Despite the extensive focus on CT applications for students, research on the role of teachers in developing CT skills remains limited. This study aims to analyze publication trends, researcher collaboration, and dominant keywords in CT-related research focusing on elementary school teachers from 2015 to 2024. A bibliometric analysis method was employed using data retrieved from Dimensions.ai, which was further analyzed with VOSviewer software. The analysis included mapping author collaboration networks, keyword co-occurrence, and inter-country relationships using bibliographic coupling techniques. The findings show a significant increase in CT-related publications among elementary school teachers, especially after 2018, with a peak in 2023. Key contributors such as Nasri, Hermita Neni, and Fendrik Muhammad emerged as central figures in

advancing CT teaching resources. Keyword analysis revealed that discussions around teacher roles, CT skills, and challenges in implementation dominate the literature. Globally, the United States, Germany, and China are leading in CT research, while Indonesia has made substantial strides in international collaboration. These findings indicate an expanding interest in CT research among elementary school educators and highlight the critical need for more studies focusing on enhancing teachers' CT skills through professional training and resource development. This study provides valuable insights into the evolving landscape of CT-related research and its implications for improving teacher competencies in digital learning environments.

Keywords: Computational thinking, teacher, primary school

INTRODUCTION

Computational Thinking (CT) is a thinking process that involves solving problems using computational concepts. According to Wing (2006) CT is a skill that allows a person to formulate problems and solutions in a way that allows computing to be carried out effectively. CT covers several important aspects such as decomposition (breaking down big problems into smaller problems), pattern recognition (recognizing repeating patterns), abstraction (focusing on important information and ignoring irrelevant details), as well as algorithms (developing step-by-step solutions) (Tang et al., 2020). CT is not only relevant in the field of information technology, but also as an essential basic skill in various disciplines. At the primary education level, the introduction of CT is essential to equip students with critical, creative, and analytical thinking skills, which are the foundation for future mastery of various fields of science (Romandoni et al., 2023; Tsarava, 2022). Thus, the application of CT in the basic education curriculum can help students understand abstract concepts and develop better problem-solving skills.

CT has been widely recognized as a basic skill that every individual must possess in this digital age. Incorporating CT into the primary education curriculum is an important step to equip students with critical and logical thinking skills from an early age. Introduction to CT at the elementary level not only helps students in understanding computing concepts, but also in developing relevant problem-solving skills in various fields (Fagerlund & Häkkinen, 2021). In addition, CT can be integrated into a variety of subjects, such as math, science, and language, thus supporting the development of cross-disciplinary skills (Nuzzaci, 2024; Chalmers, 2018). This interdisciplinary approach encourages students to apply CT in diverse contexts, allowing them to develop a holistic understanding of its applications. Basic education that integrates CT can provide a solid foundation for students to adapt to future challenges, particularly in a rapidly evolving technological landscape.

The role of teachers in the implementation of CT in primary schools is very crucial, they are not only responsible for teaching CT concepts, but also integrating them into an effective and relevant learning process Teachers must be able to facilitate students in understanding computational thinking through various approaches, such as project-based learning, exploration of real problems, and the use of technological tools (Kuncahyono et al., 2020). However, the success of the implementation of CT is highly dependent on the understanding and skills of the teachers themselves in CT. Teachers need to possess a deep understanding of CT principles and how these principles can be applied across various subjects. Therefore, it is important for teachers to receive adequate

training and support so that they are able to teach CT effectively and motivate students to think critically and creatively in problem-solving. Previous studies have shown that the application of CT in primary schools often depends on the teacher's ability to integrate these concepts into the subject matter. In addition, adequate training and professional development for teachers is also an important factor in ensuring the successful implementation of CT in the classroom (Abar, 2021; Brackmann, 2017).

However, there are still challenges in preparing teachers to teach CT, especially in developing countries, where access to resources and training is often limited. While many teachers acknowledge the importance of CT, they frequently face difficulties in translating theoretical knowledge into practical classroom activities. This gap between understanding and practice underscores the need for structured professional development programs tailored to the unique challenges faced by educators in different regions. In many cases, the lack of clear guidelines and examples for integrating CT into existing curricula further complicates its implementation. Teachers often rely on traditional teaching methods and may struggle to adopt innovative strategies required for CT education. Therefore, targeted interventions, such as curriculum development workshops and access to teaching resources, are essential to bridge this gap.

In addition to training, support systems and infrastructure also play a significant role in the effective integration of CT in primary schools. Access to technology, such as computers and internet connectivity, is a fundamental requirement for teaching CT effectively. Schools in underprivileged areas often lack these resources, limiting their ability to implement CT programs (Maharani et al., 2021).. Moreover, the rapid pace of technological advancements necessitates continuous updates to teaching materials and methodologies. Teachers require ongoing support to stay updated with the latest tools and techniques in CT education. Collaborative platforms and professional learning communities can provide teachers with opportunities to share experiences, exchange ideas, and learn from best practices in CT education globally.

Research trends related to CT competency in teachers are still relatively limited, especially at the basic education level. Many teachers find it difficult to understand how to integrate CT into more conventional subjects, such as math and science. For instance, while math inherently involves algorithmic thinking, teachers may lack the expertise to connect these concepts explicitly to CT principles. Similarly, in science education, opportunities to apply decomposition and pattern recognition in problem-solving are often overlooked. These challenges highlight the need for a clear mapping of research trends and identification of obstacles faced by teachers in mastering CT. Such insights can inform the design of more effective strategies and interventions to enhance CT education at the elementary level.

This study aims to analyze trends and patterns in research on Computational Thinking ability in elementary school teachers through a bibliometric approach. Bibliometrics is a research method used to analyze scientific literature using quantitative data, such as the number of publications, citations, and collaborations between authors (Muhammad et al., 2023; Rafiq et al., 2023). Bibliometric research allows researchers to map the development of a field of science, identify research trends, and measure the impact of a publication or author in a particular discipline. In the context of research on Computational Thinking, bibliometric methods can be used to see how this topic has been studied and published, as well as to understand the relationships between authors and institutions that contributed to the development of this research. Analysis techniques such

as co-authorship, bibliographic coupling, and co-citation are often used to explore research collaboration and impact (Maharani et al., 2020; Sohrabi & Mashhadi, 2022).

Using a bibliometric approach, researchers were able to identify the most frequently discussed topics, publishing trends, and gaps in research on CT among primary school teachers. For example, bibliometric analysis can reveal which countries and institutions are leading in CT research, as well as the predominant themes and methodologies used in recent studies. This information is invaluable for identifying areas that require further exploration and for fostering international collaboration in CT education. Through bibliometric analysis, this study will identify publication trends, collaboration maps between authors, and the most discussed topics related to CT skills in teachers. The results of this study are expected to provide insight into the direction of research in this field, as well as help educators and policymakers to design more effective training programs in the development of CT skills in elementary school teachers.

This research is also significant in uncovering existing research gaps and proposing steps to advance studies in the field of CT. For instance, while much of the current literature focuses on the theoretical aspects of CT, there is a need for more empirical studies examining its practical implementation in diverse educational contexts. Additionally, research exploring the long-term impact of CT education on students' cognitive development and career trajectories remains limited. Addressing these gaps can contribute to a more comprehensive understanding of CT and its potential to transform education. By highlighting these areas, this study seeks to guide future research efforts and support the development of effective CT education strategies. Ultimately, the findings of this research aim to empower teachers, enhance student learning experiences, and ensure that primary education systems are well-equipped to meet the demands of the digital age.

METHOD

This study used a bibliometric approach to analyze publication trends and research collaboration patterns related to Computational Thinking (CT) skills in elementary school teachers. The bibliometric approach was chosen because it is able to provide a comprehensive overview of research developments in a field, both in terms of publication distribution, collaboration between authors, and research topics that are often discussed. Bibliometric methods are particularly effective in summarizing large volumes of academic literature, enabling researchers to uncover patterns and insights that might not be apparent from individual studies. This bibliometric analysis was carried out to identify trends, associations between authors, and keywords that most often appear in related literature.

The source of this research data was obtained from the Dimension Ai journal database, which provides access to scientific articles and proceedings from various disciplines. This database was selected for its extensive coverage of interdisciplinary research and its user-friendly features for exporting citation and publication data. Data was collected using the keywords "computational thinking" and "elementary school teachers," resulting in 263 publications. The process of selecting keywords was carried out carefully to ensure the scope of the data was both comprehensive and relevant to the study’s objectives. By focusing on these keywords, the research ensured that the collected data emphasized the intersection of CT concepts and their implementation by elementary school educators. This keyword was chosen to ensure that the literature obtained is related

to the topic of Computational Thinking in the context of basic education, especially for teachers.

The inclusion criteria in this study are scientific articles and proceedings published in indexed journals, which specifically discuss Computational Thinking and the role of elementary school teachers. Articles that include empirical studies, theoretical frameworks, or reviews related to CT education in primary schools were prioritized, as these provide the most valuable insights into teaching practices and trends. In contrast, exclusion criteria include publications that are not in the form of journal or procedural articles, such as books and research reports, as well as articles that do not focus on elementary school teachers or that are irrelevant to CT topics. After going through these criteria, there are 169 publications left. The filtering process was systematic, involving multiple stages of review to ensure the final dataset was robust and accurately represented the research landscape. The bibliometric research flow is presented in Figure 1.

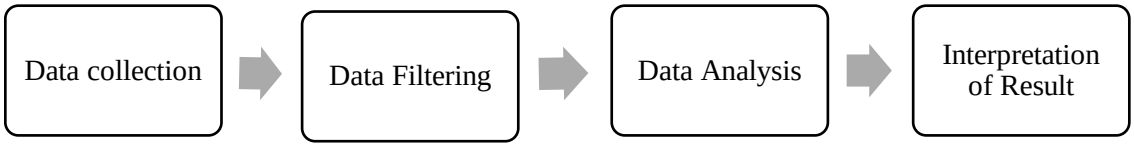

Figure 1. Bibliometric Research Flow

To analyze the data, a bibliometric analysis tool such as VOSviewer is used, which serves to visualize the relationships between bibliographic elements such as authors, keywords, and citations. The data that has been collected are analyzed using several bibliometric analysis techniques. Publication Trend Analysis is used to look at the development of the number of publications related to Computational Thinking in elementary school teachers over the past few years, with the aim of identifying a surge or decrease in research activity in this area. The Author Network Map through Co-Authorship analysis helps map collaboration between authors in the analyzed articles, so as to identify the most active and widely collaborating authors or groups of authors in CT research. Keyword Co-Occurrence Analysis is used to identify keywords that often appear together in publications, in order to reveal research topics that are often discussed related to CT in elementary school teachers. Meanwhile, Bibliographic Coupling is used to analyze relationships between articles based on the same references, which is useful for finding articles with similar literature bases as well as identifying research groups with similar interests or topic focuses.

FINDINGS AND DISSCUSION

Publication Trend Analysis

The data in the graph in Figure 2 shows the number of publications related to "Computational Thinking" involving "Elementary School Teachers" from 2015 to 2024. In 2015-2017 No publications were recorded during this period, suggesting that research or attention to Computational Thinking (CT) among primary school teachers may not have begun or been documented. There was a small increase with 1 publication in 2018. It indicates the beginning of interest or study related to CT is starting to gain attention among elementary school teachers. Furthermore, Publications increased gradually. In 2019, 2 publications were recorded, then increased again in 2020 (8 publications), and 2021 (14 publications). This shows that there is a consistent upward trend, albeit relatively

slowly. In 2022, there was a significant increase with 32 publications. This indicates that the topic of CT in elementary school teachers has received much greater attention compared to previous years. The peak with 80 publications occurred in 2023, indicating a large spike in the number of related research or publications. This may reflect the development of greater educational trends, curriculum adoption, or a higher awareness of the importance of CT in primary education. The data for 2024 shows a significant decrease of up to 33 publications, but this may be due to data that is still running (year-to-date) or has not covered the entire year. The data was taken on September 17, 2024.

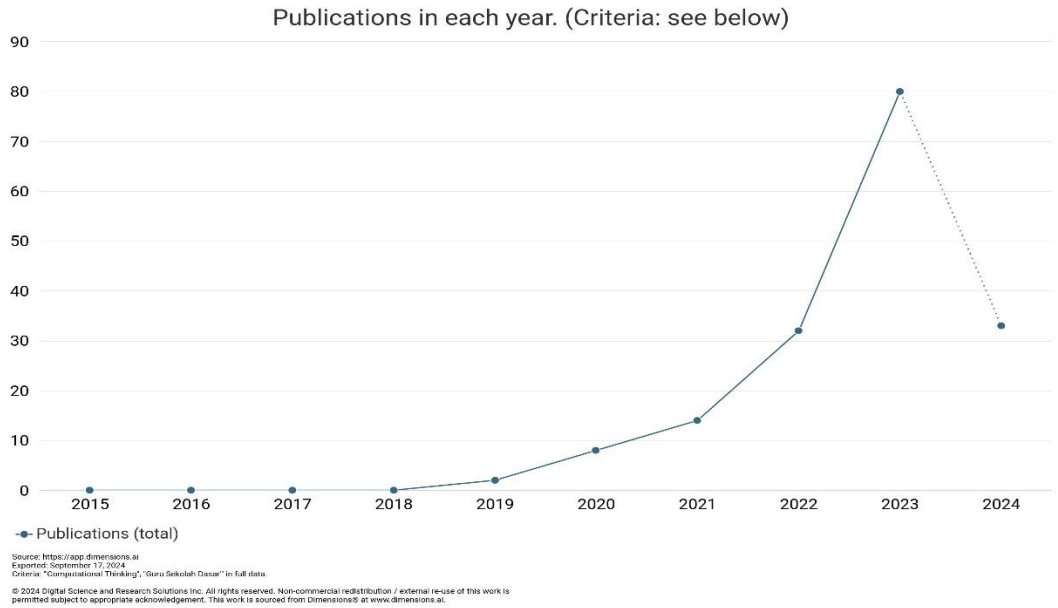

Figure 2. Publication Trend

From this graph, it can be concluded that research on Computational Thinking (CT) in elementary school teachers has increased sharply, especially since 2020. This surge is likely influenced by the push to integrate computational thinking skills into the basic education curriculum, in line with digital transformation and the demands of technology-based education. The integration of CT into elementary education has become a strategic priority in many countries, as it prepares students to face the challenges of a rapidly evolving technological landscape. Furthermore, the COVID-19 pandemic, which accelerated the adoption of digital tools and online learning, may have contributed to the heightened attention on CT competencies among educators. This graph also reflects the growing need to involve primary school teachers in improving computational thinking skills, which may be related to the implementation of STEM (Science, Technology, Engineering, and Mathematics)-based curricula in elementary schools. This alignment emphasizes the critical role of teachers in bridging traditional teaching methods with modern pedagogical approaches that incorporate CT concepts.

Moreover, the upward trend in research publications highlights a shift in focus towards practical applications of CT in the classroom, including teacher training programs and the development of innovative teaching tools. Researchers have increasingly explored the barriers and opportunities associated with integrating CT into elementary education, shedding light on the gaps in teacher preparedness and access to resources. As the demand for computational skills continues to grow, so too does the urgency to equip teachers with the necessary knowledge and strategies to foster these skills in young learners. The findings from these studies not only inform policy but also

provide actionable insights for curriculum designers, educators, and stakeholders invested in advancing educational outcomes in the digital era.

Author Network Map Analysis

Furthermore, the analysis of the author's network map is shown in figure 3. The image comes from Vosviewer by inputting publication data that has been extracted from the ai dimension and then analyzed by Co-Authorship analysis, showing several nodes representing authors in the CT research collaboration network. The relationships between nodes indicate the collaboration of authors in the analyzed article. From the map, writer Nasri occupies a central position, indicating that he is actively collaborating with other writers. In addition to Nasri, Hermita Neni, Fendrik Muhammad, and Alexander also showed a wide connection in the collaboration, indicating their significant contribution to the CT research of elementary school teachers, especially on the topic of media development (Alim et al., 2022; Putra et al., 2023).

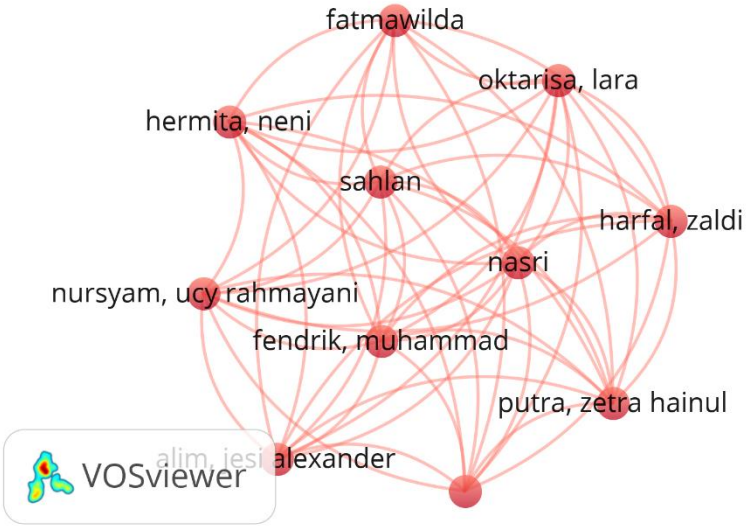

Figure 3. Co-Authorship

The network also uncovered some strong collaboration groups. For example, Fatmawilda, Oktarisa Lara, and Sahlan formed a group with intensive collaboration, indicating the existence of a joint project or the same research topic. The research topic on this topic is the computational thinking ability of elementary school teachers (Putra et al., 2023; Rohmatulloh et al., 2023). In addition, authors such as Nasri and Putra Zetra Hainul are in strategic positions with high connectivity, acting as liaisons between various research groups, allowing them to contribute to cross-topic and group research.

This network map provides many benefits for research. One of the advantages is the identification of key authors who can assist new researchers in finding key figures for further collaboration. By identifying prolific and influential authors, new researchers can also gain insights into the methodologies and perspectives that dominate the field, helping them align their research with established trends. The network also makes it easier for researchers to identify research groups that focus on specific topics and assess research gaps. For instance, recognizing clusters of researchers working on CT integration in STEM education can help pinpoint areas where interdisciplinary collaboration might yield impactful results. Knowledge of these collaboration patterns can strengthen academic networks, encourage new collaborations, and advance CT research, especially

among elementary school teachers. Furthermore, understanding these networks can guide funding agencies and academic institutions in targeting support for underexplored areas, thereby fostering a more balanced and comprehensive growth of the field.

Keyword Co-Occurrence Analysis

Figure 4 shows the results of **Keyword Co-Occurrence** analysis conducted using VOSviewer. This analysis aims to identify keywords that often appear together in various publications related to the topic of **Computational Thinking (CT)** in elementary school teachers. Keywords that frequently appear together are indicated with interconnected nodes, while node size describes the frequency of occurrence of those keywords in the analyzed publications. In this visualization, it can be seen that the keywords **teacher**, **computational thinking skill**, and **problem** have a direct relationship. **Teacher** emerges as the center of a variety of related topics, indicating that the role of teachers in CT learning is the dominant theme in the literature. The direct relationship between **teachers** and **computational thinking skills** indicates the importance of computational thinking skills that teachers have in the teaching process in elementary schools.

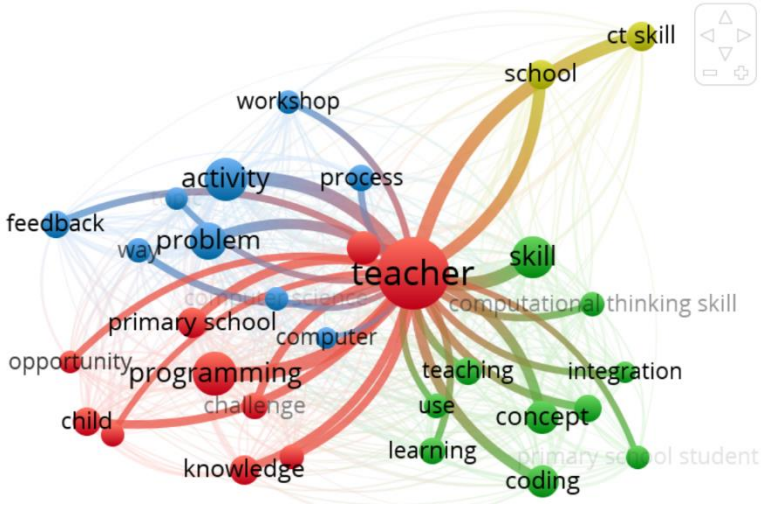

Figure 4. Keyword Co-Occurrence

In addition, the relationship between **teachers** and **problems** shows that there are problems faced in developing or implementing CT skills among teachers. These issues can be a lack of training, limited resources, or other challenges in integrating CT into the primary school curriculum (Ping et al., 2021). The strong relationship between **problem** keywords and **CT skills** also shows that teachers' CT skills may still need further development, which can be a challenge in the CT learning process in primary schools. **Dominant Topic Groups** Other keywords such as **programming**, **knowledge integration**, and **learning** are also closely linked to **teachers**, suggesting that CT learning is often related to programming concepts and the integration of these skills into teaching and learning activities. This indicates that the research conducted not only focuses on the theoretical aspects of CT, but also on practical ways of teaching it, such as through teaching programming.

Significance in CT Research on Elementary School Teachers From this analysis, it can be concluded that there is a strong focus on the role of teachers in the development of CT skills of elementary school students. However, the existence of a significant relationship between **teachers**, **problems**, and **computational thinking skills**

shows that there are challenges that need to be overcome in an effort to improve teachers' CT skills. This challenge can come from the lack of experience of teachers in using related technology or difficulties in implementing CT-based teaching methods. This **Keyword Co-Occurrence** analysis provides in-depth insight into the main themes discussed in the literature related to CT in elementary school teachers. The focus on teachers and the challenges they face in teaching CT, as shown by the relationship between **teacher keywords**, **computational thinking skills**, and **problems**, provides clues that there is a need for more research and development in this area. Future research may pay more attention to efforts to improve teachers' CT skills through specialized training or the development of supportive teaching resources.

Bibliographic Coupling

Figure 5 shows the results of the Bibliographic Coupling analysis by country, which is analyzed using VOSviewer with a minimum threshold of 1 document and 1 citation owned by a country. Bibliographic Coupling is an analysis technique that links articles or countries based on the same reference (Dagienė et al., 2022). In this case, countries with documents that have the same reference are depicted as interconnected in the map.

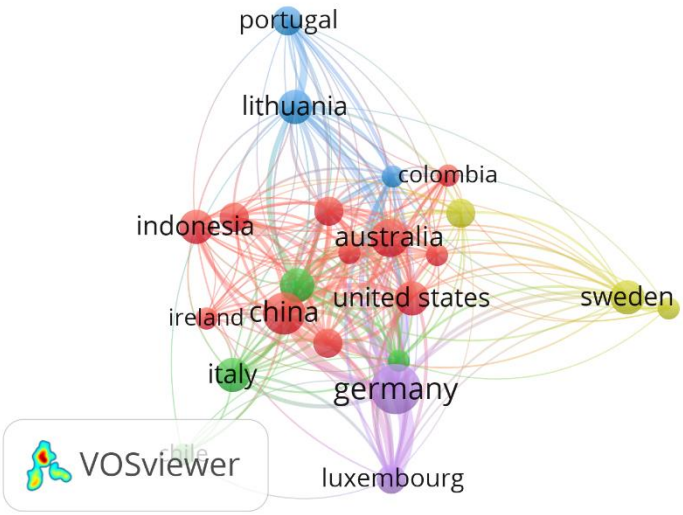

Figure 5. Bibliographic Coupling Country

Research on Computational Thinking (CT) in elementary school teachers shows a growing trend of global collaboration, as shown in the BIBLIOMETRIC visualization based on VOSviewer software. This network describes the interaction between countries in CT research publications, where developed countries such as Germany, the United States, and Australia become centers of collaboration with high publication frequency and extensive network of connections. The size of the nodes and the thickness of the lines connecting these countries indicate that they have a dominant role in the development and dissemination of CT-related knowledge at the global level.

In addition to developed countries, several developing countries such as Indonesia, China, and Italy are also seen to be active in this collaboration network. Indonesia, for example, is beginning to show an increase in its contribution to CT research through collaboration with other countries in Asia and Europe. This participation reflects the efforts of developing countries to integrate CT into the basic education curriculum as

an essential foundational skill in the digital age. Previous research by Romandoni et al., (2024); Setiawan, (2021)emphasized that although developing countries face challenges in the adoption of educational technologies, international collaboration can accelerate the process of adaptation and effective implementation of CT in primary schools.

However, not all countries have equal access to this research network. Countries like Portugal, Lithuania, and Colombia appear to have a more limited contribution with fewer connections. These limitations may be due to a lack of research resources, financial support, or barriers to cross-border collaboration, such as language and cultural differences. To overcome these challenges, greater initiatives are needed to strengthen inclusive international collaboration networks, especially between developed and developing countries.

International collaboration in CT research is essential because it allows for the exchange of knowledge and experience across different educational contexts. According to Cahyaningtyas & Desstya, (2024) the adaptation of CT in a local context can increase the relevance and effectiveness of its application in various countries. Therefore, future research should be focused on the development of CT-based adaptive curricula that are suitable for local needs, as well as the evaluation of the effectiveness of its implementation through collaboration between academics and education practitioners.

Overall, these bibliometric visualizations show that although dominance is still held by developed countries, developing countries' participation in computational thinking research is increasing. By strengthening the international collaboration network, it is hoped that this research can make a significant contribution to improving the quality of basic education globally, making CT a basic skill possessed by future generations in various parts of the world.

CONCLUSION

The conclusion of this study shows that Computational Thinking (CT) in the context of elementary school teachers has experienced significant development in recent years, both in terms of the number of publications and collaboration between researchers. Publication trends show a sharp increase since 2018, with a peak in 2023, reflecting the growing attention to the importance of CT among primary school teachers. Although there is a decrease in the number of publications in 2024, this can be explained by data that is still ongoing and does not cover the entire year. The study also uncovered a strong group of collaborations among specific authors, suggesting the existence of in-depth joint projects related to the CT abilities of primary school teachers. Keyword Co-Occurrence analysis shows that the role of teachers, computational thinking skills, and problems related to the application of CT are the dominant topics in the literature. The strong association between keywords such as teacher, computational thinking skills, and problems shows the challenges faced in developing CT skills among teachers, such as limited training and resources. The Bibliographic Coupling analysis revealed that countries such as the United States, Germany, and China played an important role in disseminating CT-related literature and research, while countries such as Indonesia, Australia, and Italy showed strong collaborations with other countries. This indicates that CT-related research among primary school teachers is global and cross-country, with several countries serving as reference centers in the study. Overall, the study identified an increase in interest in CT topics among primary school teachers, with growing collaboration between researchers and between countries. Despite the challenges in the implementation of CT in primary schools, this analysis provides important insights for

future research, which could focus on improving training and resources to support computational thinking skills among teachers.

To further advance Computational Thinking (CT) in primary education, a comprehensive approach is necessary. Targeted teacher training programs should be developed to equip educators with the requisite CT knowledge and pedagogical skills. Integrating CT concepts into core curriculum subjects can provide a seamless and meaningful learning experience for students. Additionally, the development of high-quality, accessible resources, such as lesson plans, activities, and digital tools, can support teachers in effectively implementing CT in their classrooms. Fostering international collaboration among researchers can facilitate the sharing of best practices, identification of emerging trends, and addressing common challenges in CT education. Finally, advocating for supportive educational policies that prioritize CT and allocate adequate funding is crucial for its successful implementation. By addressing these key areas, we can empower teachers to effectively integrate CT into their classrooms, fostering a generation of students equipped with essential 21st-century skills.

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