Journal of Curriculum and Learning Technologies (JCLT-Krisno)

Volume 1 Number 1 June 2025
Available online at
Email: cilt-krisno@almaarif.ac.id | E-ISSN: xxxx-xxxx | Published by Al-Ma'arif Institute Way Kanan

Research Trends in the Application of the CTL Model in Mathematics Education: Bibliometric Analysis of Publications 2020–2025

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How to cite: Maryani, M. & Hasanudin, H. (2025). Research Trends in the Application of the CTL Model in Mathematics Education: Bibliometric Analysis of Publications 2020–2025. *Journal of Curriculum and Learning Technologies (JCLT-Krisno)*, *1*(1), 29-38. https://journal.almaarif.ac.id/index.php/krisno/article/view/657

ABSTRACT: This study aims to analyze the development of the application of the Contextual Teaching and Learning (CTL) model in mathematics learning through a bibliometric approach. The bibliometric method maps scientific publication trends, number of citations, research collaboration, and dominant CTL topics. Data were obtained from Google Scholar using the Publish or Perish application and were visualized using VOSviewer software to identify clusters of related keywords and research patterns. The results of the analysis of 100 selected articles published between 2020 and 2025 show that the primary focus of the research is on the effectiveness of the CTL model in improving students' conceptual understanding, critical thinking skills, and learning motivation in mathematics. Keyword mapping produced eight major topic clusters, such as the influence of the model on students, its practical application in classroom settings, challenges in implementation, particularly at the elementary school level, and the evaluation of learning models. Interestingly, it was found that although research on CTL is growing rapidly, there are still several under-explored areas, including the integration of digital learning media, the role of teacher competence in applying CTL, and longitudinal studies measuring long-term impacts. These gaps indicate potential areas for future research. Additionally, few studies have explored the influence of socio-cultural context on the success of CTL implementation. This study is expected to provide a thematic overview and a foundation for researchers and educators to identify meaningful directions for future exploration and innovation in mathematics education using the CTL model.

Keywords: : *Contextual Teaching And Learning, Mathematics Learning, Bibliometric Analysis*

I. INTRODUCTION

Mathematics education is important in developing students' logical, critical, and creative thinking skills. However, teaching approaches that tend to be abstract and lack connection to real-life experiences often make it difficult for students to understand concepts and discourage them from relating mathematics to their daily lives (Fauzi & Yuliana, 2020; Astuti, 2023). This lack of interest and understanding hurts students' learning outcomes.

The Contextual Teaching and Learning (CTL) approach is suitable for addressing this issue as it emphasizes a strong connection between learning materials and real-life situations experienced by students. CTL integrates principles such as constructivism, inquiry, questioning, community-based learning, providing examples, reflection, and authentic assessment (Ulfadhilah & Sari, 2024). Thus, CTL encourages meaningful, collaborative learning activities focusing on problem-solving so students understand formulas and interpret and apply concepts functionally.

Various studies have shown that implementing CTL can improve students' understanding of mathematical concepts, increase learning motivation, and reduce anxiety towards mathematics. For example, implementing CTL combined with video media has been proven to improve learning outcomes and student motivation compared to traditional learning (Siregar et al., 2025). Additionally, other research has found that this model can reduce math anxiety while improving learning outcomes for elementary school students (Yunitasari et al., 2023). These findings reinforce the role of CTL as a more relevant learning approach aligned with students' real-life contexts.

Although research on CTL is growing, comprehensive studies that map out the main themes, patterns of collaboration between researchers, and research gaps are still rare. Therefore, a bibliometric analysis is needed to provide a comprehensive overview of the dynamics of CTL research development, dominant topics, and potential research directions for future development (Wijayanti, 2024). Therefore, this study aims to map publications on CTL in the context of mathematics education over 2020–2025 to identify trends and formulate recommendations for the following research agenda.

II. METHOD

This study applies a bibliometric approach to evaluate scientific literature discussing the application of the Contextual Teaching and Learning (CTL) model in the context of mathematics learning. To ensure the reliability and quality of the data sources, the articles used were obtained from two well-known scientific databases, Scopus and Web of Science (WoS), which are known for their coverage of reputable journals with a rigorous selection process. The selection of these two databases was intended to ensure the accuracy and validity of the analysis results. Data collection was carried out using the Publish or Perish (PoP) software, employing a combination of keywords such as "Contextual Teaching and Learning" and "mathematics education," "CTL model" and "mathematics learning," as well as "application of CTL in mathematics education." The publication timeframe was set between 2020 and 2025 to ensure the analysis remains relevant to current research developments. From the initial search results, a total of 386 articles were identified, 204 from Scopus and 182 from WoS..

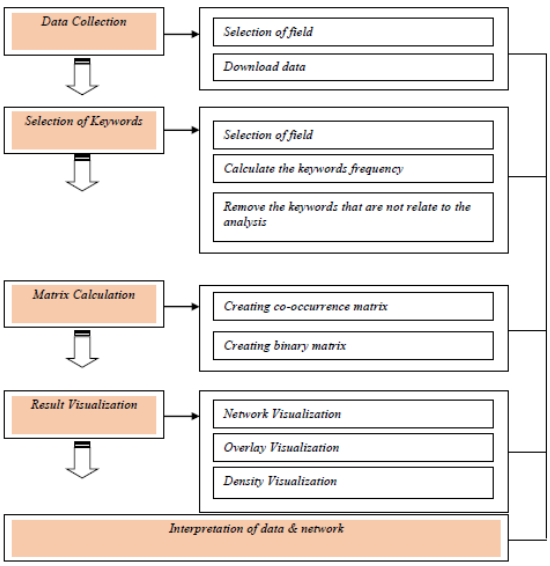


Figure 1. Data Classification Strategy

After the data was collected, a screening process was carried out in several stages. First, articles were selected based on document type, including only journal articles and excluding other types such as proceedings, reviews, and editorials. The second stage involved content analysis

through titles and abstracts to ensure the articles discussed CTL's application in mathematics learning. Finally, duplicate articles across databases were manually eliminated. This entire selection process yielded 100 articles suitable for further analysis. The filtered bibliographic data was exported in .ris (Research Information System) format and analyzed using VOSviewer software. This analysis included three primary forms of visualization: network visualization to map the relationships between keywords and authors, overlay visualization to show the development of topics over time, and density visualization to identify areas with the highest frequency of discussion. This series of processes followed the five stages of bibliometric analysis proposed by Chen et al. (2016), namely: (1) data collection, (2) keyword selection, (3) construction of a co-occurrence matrix, (4) data visualization, and (5) interpretation of the network and research trends. Using this approach, the study aims to present a thematic map of the development of CTL research in mathematics education and to identify areas of study that remain open for further exploration.

III. RESULT

Keyword mapping using VOSviewer software identified eight main clusters reflecting the dominant focus in research on applying the Contextual Teaching and Learning (CTL) model in mathematics learning. These clusters show strong thematic connections, particularly in terms of the influence of CTL on learning outcomes, critical thinking skills, and student motivation. Prominent topics such as "conceptual understanding," "mathematical problem-solving," and "model effectiveness" can be explained through a constructivist approach, which forms the theoretical foundation of CTL. John Dewey emphasized the importance of meaningful and contextual learning experiences, while Lev Vygotsky highlighted the role of social interaction and the zone of proximal development in the learning process.

Therefore, the emphasis on enhancing conceptual understanding and critical thinking skills reflects the direct application of these theories in mathematics education. However, the analysis also revealed significant conceptual gaps. Some topics, such as the use of technology-based learning media, the assessment of teachers' competencies in implementing CTL, and longitudinal studies on the long-term impact of this model, are still rarely the focus of research. Clusters with keywords such as "digital media" and "teacher competencies" only appear limited, indicating that technology's use to connect learning with the real-world context has not yet become a primary concern. However, in 21st-century education, technology plays a crucial role in creating relevant and meaningful learning experiences. The lack of exploration into the role of teachers also suggests that many studies still focus on student learning outcomes without considering mediating factors such as teachers' competencies and teaching strategies. This gap presents both a challenge and an opportunity to expand the scope of CTL research, including improving the quality of its implementation at the practical level.

Compared to research trends in other countries, such as China and Malaysia, studies on CTL are more advanced, particularly in integrating aspects of technology and local culture. For example, CTL has been widely applied in project-based and collaborative learning based on advanced technology in the United States. In contrast, CTL research in Indonesia focuses on conventional learning outcomes such as score improvement and concept understanding but has not yet extensively explored cross-cultural aspects, digital platform integration, or more personalized and adaptive learning approaches. The density visualization of the mapping also shows that terms like "student" and "CTL learning model" have high dominance, indicated by their size and bright color in the map. Conversely, keywords like "learning technology" and

"socio-cultural" appear small or are absent in some visualizations, indicating that these themes have not yet become the primary focus of research. The conclusion from these findings confirms that although CTL has been extensively researched, the comprehensive development of this model, especially considering technological aspects, the role of teachers, and local cultural values, still holds significant potential for further exploration. Developing a more reflective and responsive CTL approach to modern learning challenges, such as hybrid learning models and data-driven personalization, could be a strategic direction for future mathematics education research in Indonesia.

Tabel 1. Article Classification

Year of Publication	Number of Publications
2020	18
2021	24
2022	18
2023	18
2024	18
2025	4
Jumlah	100

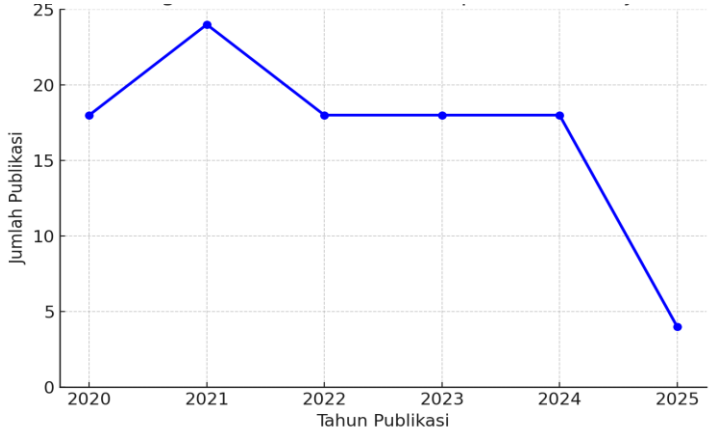


Figure 2. Level of development of Contextual Teaching and Learning model research in mathematics learning.

Table 1. Topic and keyword calcification

No.	Color	Topic Focus	Dominant Keywords	Representative Article
1	Red	The impact of CTL on student learning outcomes and skills	"concept understanding", "critical thinking", "learning outcome	Amelia & Hartati (2023); Rahmawati & Yusuf (2021)
2	Purple	Implementation and effectiveness of CTL model in learning	"effectiveness", "implementation", "learning strategy"	Gufron (2022); Fitriyani & Supriyadi (2022)
3	Blue	Hands-on CTL practice in the classroom and evaluation of implementation	"classroom application", "reflection", "authentic Assessment"	Muzdalifah & Yuliana (2021); Nainggolan et al. (2024)

4	Yellow	Theoretical aspects and basic principles of CTL	"constructivism", "learning community", "inquiry"	Hasibuan (2014); Ulfadhilah & Sari (2024)
5	Green	Context-based math learning and problem solving	math problem", "contextual", "real world context "6	Putra & Hasanah (2025); Adha et al. (2019)
6	Orange	Implementation challenges in primary schools	implementation constraints", "SD", "misapplication	Anggreni et al. (2019); Siregar & Harahap (2019)
7	Chocolate	Evaluation of learning models and development of other models	"learning model", "evaluation", "model development"	Wardani et al. (2024); Pratiwi & Nugraha (2024)
8	Dark blue	Mathematics as the main domain of CTL implementation	mathematics", "mathematics learning", "mathematical concepts"	Monalisa & Anggo (2025); Handayani & Anwar (2024)

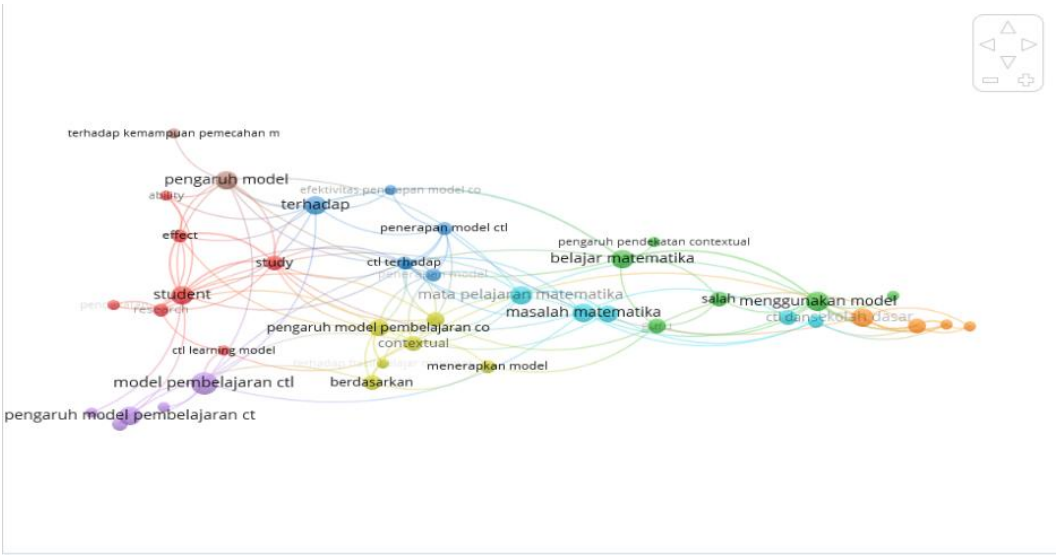


Figure 3. Visualization of the Contextual Teaching and Learning Model Network in Mathematics Learning

The cluster analysis results illustrate the relationships between keywords in each group. Each keyword is marked with a colored circle, where the size of the circle reflects how often the word appears. The more often a keyword appears in the title and abstract, the larger the circle. General keywords are usually displayed with larger circles.

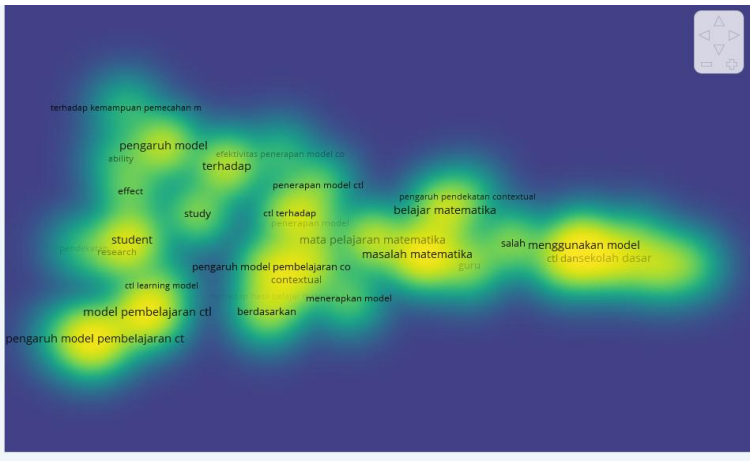


Figure 4. Visualization of the Contextual Teaching and Learning Model in Mathematics Learning

Figure 4 presents a density visualization illustrating the concentration levels of key terms in studies on applying contextual teaching and learning (CTL) models in mathematics education. Bright yellow areas represent regions with high frequency and strong interrelationships between terms, while blue areas indicate terms that appear infrequently or have weaker relationships. Based on the density mapping results, the terms with the highest density include "mathematical problems," "mathematics subject," and "using models." This finding indicates that the primary focus revolves around applying the CTL learning model in solving mathematical problems. Meanwhile, terms such as "student," "model influence," and "CTL learning model" also show medium to high density, emphasizing that the role of students and the effectiveness of CTL model application are crucial aspects within the scope of the study. Overall, this visualization confirms that most studies emphasize the effectiveness of the CTL model in mathematics learning and its implications for students.

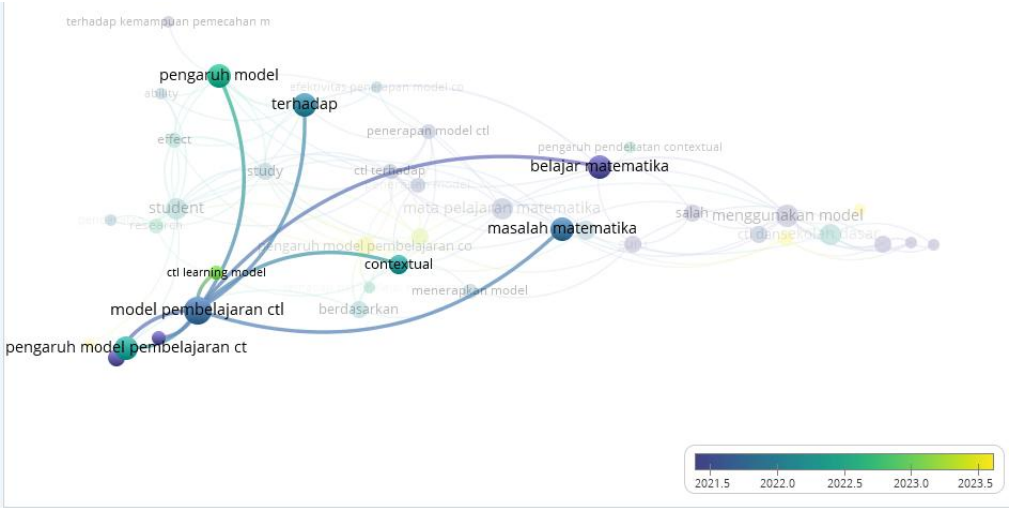


Figure 5. Visualization of the Contextual Teaching and Learning Model Overlay in Mathematics Learning

The overlay visualization shown in Figure 5 illustrates the trend of research development related to terms associated with project-based learning models in mathematics education. This visualization shows several topics often the focus of such studies, such as mathematics learning and the Contextual Teaching and Learning (CTL) approach.

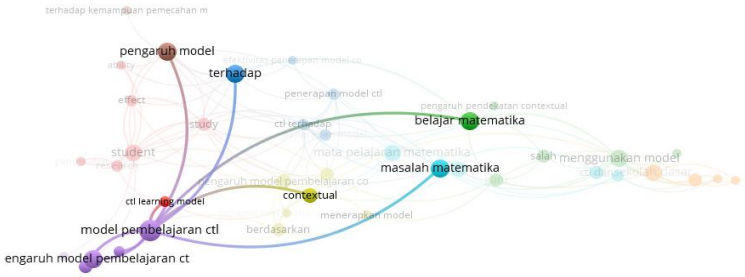
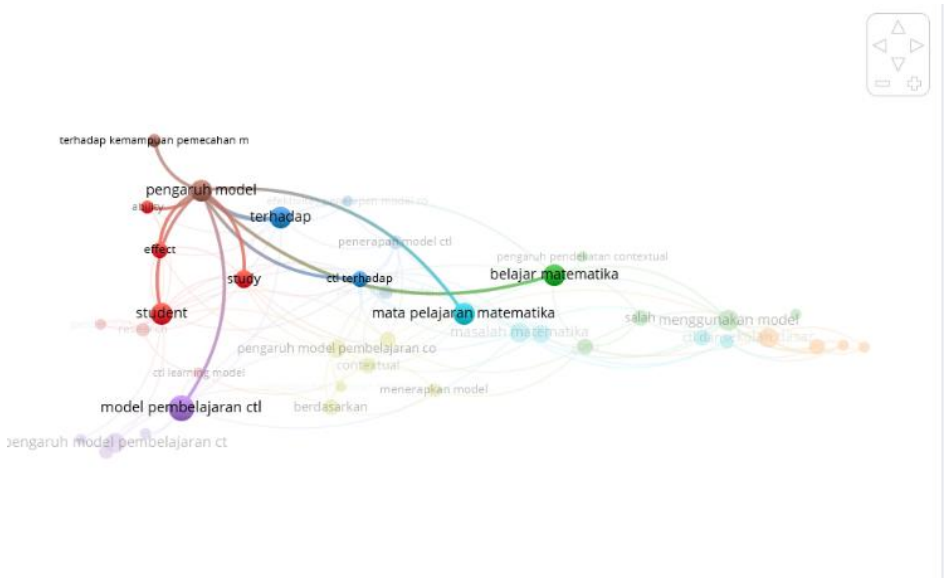


Figure 6. Visualization of CTL model terms

Figure 6 illustrates the close relationship between the CTL learning model and several other terms, such as model influence, contextual, mathematics learning, and mathematics problems. Meanwhile, Figure 7 shows that the relationship between mathematics problems and contextual is evident, indicating that the contextual approach is often used in solving mathematics problems by applying the CTL learning model.



Figur 7. Visualization of the effect of CTL model

The results of data analysis indicate that various topics related to the CTL model in mathematics learning have been the focus of several studies. Studies on these topics are expected to contribute relevant and up-to-date findings related to applying the CTL model in the context of mathematics learning.

IV. COCLUSION

This study makes an important contribution in three main areas: conceptual, methodological, and practical. Conceptually, this study expands the theoretical understanding of implementing the Contextual Teaching and Learning (CTL) model in mathematics education, particularly concerning improving learning outcomes, critical thinking skills, and students' conceptual understanding. The findings support the constructivist theoretical foundation underlying CTL, as explained by figures such as John Dewey and Lev Vygotsky, who each emphasize the

importance of relevant learning experiences and the role of social interaction in the learning process. Furthermore, this study successfully identified conceptual gaps that have not been extensively researched, such as the use of digital technology and the contribution of teachers in implementing CTL, which have the potential to become new directions in the development of contextual learning strategies in the future. From a methodological perspective, this research contributes by utilizing a bibliometric approach assisted by the VOSviewer and Publish or Perish software, enabling systematic mapping of trends and thematic relationships in scientific literature. This approach provides a data-driven overview that can be a reference for other researchers to develop more focused, objective, and quantitative literature reviews.

Meanwhile, from a practical perspective, the findings of this study are relevant as a basis for designing mathematics learning that is more aligned with contemporary needs, whether by teachers, schools, or education policymakers. The lack of focus on technology integration and the role of teachers indicates the importance of enhancing educators' capacity through training specifically aimed at more effective and innovative CTL implementation. Additionally, the findings of this study have significant implications for educational policy. In terms of curriculum development, the results of this study can serve as a foundation for developing adaptive and collaborative CTL-based learning strategies. The government and educational institutions can also refer to these results to develop teacher training programs emphasizing the integration of learning technology and the more strategic application of contextual learning. At the educational unit level, this research can encourage schools to adopt policies that support learning innovation, including providing digital facilities and strengthening guidance for teachers in the learning process. Therefore, this research provides a comprehensive mapping of CTL development in Indonesia and offers a new direction for a more comprehensive and future-oriented transformation of mathematics learning..

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