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A Systematic Review of Research Trends on the Culturally Responsive Transformative Teaching (CRTT) Model in Science Learning

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ABSTRACT

This study conducted a systematic review of research trends on the Culturally Responsive Transformative Teaching (CRTT) model in science learning in the period 2016–2025. The methods used include collecting bibliometric data from Google Scholar assisted by the Publish or Perish and Dimensions.ai applications, as well as visualization analysis using VOSviewer to map the number of publications, distribution of document types, disciplines, keyword frequency, and keyword relationships and densities. The results show a sharp increase in the number of publications since 2020, with a peak in 2024, reflecting the increasing attention to the integration of culture and local wisdom in science education. Journal articles are the main media (55 publications), followed by edited books, chapters, proceedings, and monographs. The fields of Education and Curriculum and Pedagogy dominate the literature, while language and cultural studies have a high citation impact. Keyword analysis emphasizes the focus on the implementation of CRTT at the high school level, integration with Problem-Based Learning and local wisdom, as well as aspects of evaluation and methodology. Network, overlay, and density visualizations demonstrate the progression from theoretical concepts to transformative applied practices. Further research is recommended to explore the integration of technology, ethnoscience, and cross-disciplinary approaches to enrich CRTT implementation.

INTRODUCTION

In the era of globalization and multicultural society like today, education can no longer be separated from the social, cultural, and identity realities of students (Dishon & Gilead, 2021). Science education, as one of the important pillars in the development of 21st-century human resources, should not only emphasize the cognitive aspects and scientific skills, but also pay attention to the social and cultural dimensions of students. Unfortunately, the dominant science learning model today is still normative and universalistic, tending to ignore the local context and cultural diversity of students (Ghifari et al., 2025). This causes a cultural discontinuity between students' lives and the content and delivery of science materials in schools, which ultimately affects the low learning motivation, academic engagement, and learning achievement of students from marginalized groups (Gay, 2018; Lee, 2005).

Preparing active learning is also a government strategy to face the era of globalization and answer the demands of the 21st century (Stehle & Peters-Burton, 2019; Van Laar et al., 2020; Larson & Miller, 2011; González-Pérez & Ramírez-Montoya, 2022). This strategy is expected to produce

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individuals who are competent in technology and science so that they can advance the nation (Muliani & Citra Wibawa, 2019; Mynbayeva et al., 2015). It is known that the demands of the 21st century are the main things that must be considered, especially in the field of education to face future challenges (Geisinger, 2016; Larson & Miller, 2011; Kaufman, 2013). So, in other words, the skills needed in the 21st century must be mastered (DiCerbo, 2014; Fry & Seely, 2011; Griffin, 2017; Jang, 2016; Lambert & Gong, 2010; Sibille et al., 2010).

The Culturally Responsive Transformative Teaching (CRTT) model is presented as a promising pedagogical approach to address these challenges. CRTT is a synthesis between culturally responsive pedagogy that emphasizes the importance of recognizing students' cultural values as a source of learning, with transformative teaching that aims to form critical awareness and transformative social action (Rahmawati, Ridwan, & Agustin, 2020). In other words, CRTT not only accommodates cultural diversity, but also actively integrates it into the learning process to create a space that empowers and humanizes students.

In the context of science learning, CRTT becomes increasingly relevant because science has often been associated with the dominant culture (Western science) that is separate from local values and indigenous knowledge. In fact, various studies have shown that when students are able to connect science concepts with practices, symbols, and life experiences that they are familiar with in everyday life, their learning engagement increases significantly (Aikenhead & Michell, 2011). Concrete examples of this approach include the use of herbal medicine in biology learning, the use of traditional calendars to understand the earth's cycle, or the integration of local knowledge about conservation in ecological studies. CRTT provides space for students to feel recognized, valued, and relevant in a learning process that is often considered foreign or "not theirs."

In science learning, students are not only equipped with mastery of a number of sciences, but are also given sufficient space to apply the knowledge they have learned in everyday life (Astalini et al., 2022; Kurniawan et al., 2019; Nurlia, 2023; Darmaji et al., 2021; Kurniawan et al., 2023; Ayu Sri Wahyuni, 2022). This is because in science learning, students not only memorize concepts and answer questions, but students are also expected to be able to understand, observe, analyze, and solve problems that will later be useful in everyday life (Maison et al., 2020). With the right learning, students can participate more actively in solving problems and finding creative solutions, which ultimately increases their creative thinking competence (Sari & Wulandana, 2019).

However, although the potential of CRTT in science learning is enormous, its implementation is not easy. Teachers need to have cultural awareness, specific pedagogical skills, and flexible structural and curricular support. In addition, this approach also requires a paradigm shift in education that is not only oriented towards mastery of content, but also towards character building and social justice (Adawiyah et al., 2022). Therefore, a deep understanding of the practices, challenges, and impacts of implementing CRTT in science education is very important.

Various studies on CRTT have been conducted over the past two decades, both in the form of qualitative studies on teacher and student perceptions, development of learning models, and evaluation of teacher training programs. Unfortunately, the findings of these studies are still scattered and have not been systematically synthesized. There is no systematic review that comprehensively maps the trends, methodologies, regional focuses, and empirical and theoretical contributions of these studies in the realm of

science education. In fact, with a systematic review, we can find out how the theory and practice of CRTT have developed in the context of science learning, as well as identify research gaps that still need to be filled by further studies.

Therefore, this study aims to conduct a systematic review of research trends related to the Culturally Responsive Transformative Teaching (CRTT) model in science learning. Specifically, this study will review: (1) how publications related to CRTT in science education have developed over time; (2) the methodological approaches used; (3) the context of the population and study area; (4) the dominant themes that emerged; and (5) the contribution and implications of research results to the theory and practice of culturally relevant science education. This study is expected to provide a strong foundation for the development of more equitable, reflective, and contextual science pedagogy, as well as being a reference for teachers, researchers, and policy makers in designing science education that supports diversity.

METHODS

This study uses a descriptive and analytical approach with a systematic review design that aims to understand and describe research trends on the Culturally Responsive Transformative Teaching (CRTT) model in science learning. This systematic not only maps the distribution of publications over a certain period of time, but also evaluates the themes raised, the methodological approaches used, and the scientific contributions offered by each study.

Data collection was carried out through searching for scientific documents indexed in the Google Scholar database, supported by the Publish or Perish and Dimensions.ai applications. These tools were chosen because they have strong capabilities in collecting bibliographic metadata widely and quickly, and have been used in various bibliometric studies and systematic reviews in education (Hallinger & Chatpinyakoop, 2019; Hallinger & Nguyen, 2020).

To ensure the accuracy and representativeness of the data, the researcher established the following inclusion and exclusion criteria:

1. Inclusion Criteria

- Documents published between 2016 and 2025.
- Documents that explicitly discuss the topic of the CRTT (Culturally Responsive Transformative Teaching) model or similar approaches in the context of science education.
- Documents in the form of scientific journal articles, conference proceedings, book chapters, or edited books.
- Documents are available in full text and can be accessed in their entirety.

2. Exclusion Criteria

- Documents that are not relevant to the CRTT topic or are not in the context of science learning.
- Documents that are not available in full text version.
- Documents issued before 2016 or after 2025.

To strengthen the data analysis, this study also used VOSviewer software to conduct bibliometric analysis. VOSviewer was chosen because of its ability to visualize scientific linkage networks such as co-authorship, co-citation, bibliographic coupling, and co-occurrence of keywords, thus providing in-depth insight into the structure, dynamics, and development of research on CRTT in science education.

By utilizing VOSviewer, researchers can identify:

- Dominant keywords that frequently appear in publications,

- Collaboration between authors or institutions,
- Distribution of publications by year,
- And the thematic focus of research in the subfields of CRTT and science education.

In this study, an analysis was conducted on 200 documents that have been indexed in Google Scholar from 2016 to 2025. The selection of Google Scholar as the main source is based on the breadth of document coverage, especially for educational studies that are not always indexed in paid databases such as Scopus or Web of Science. Google Scholar also has an inclusive selection system and has been used in many previous studies for systematic reviews (Zawacki-Richter et al., 2019).

RESULTS AND DISCUSSION

This study aims to describe the research trends of the Culturally Responsive Transformative Teaching (CRTT) model in science learning conducted from 2016 to 2025. The following is Figure 1 regarding the research trends of the Culturally Responsive Transformative Teaching (CRTT) model in science learning. The following is Figure 1 regarding the research trends of the Culturally Responsive Transformative Teaching (CRTT) model in science learning.

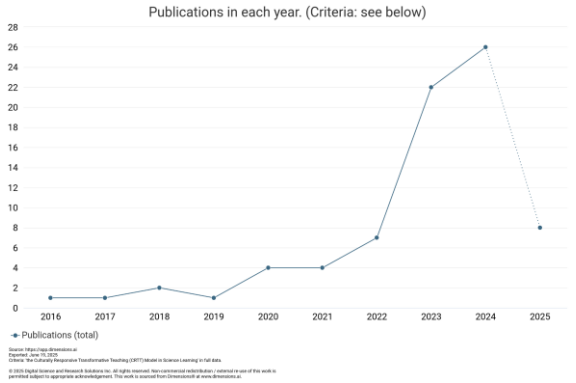

Figure 1. Research Trends on the Culturally Responsive Transformative Teaching (CRTT) Model in Science Learning

Figure 1 shows that the research trend on the Trend of Culturally Responsive Transformative Teaching (CRTT) Model in Science Learning from 2016 to 2025 has increased and. In 2016 there were 2 publications related to the Trend of Culturally Responsive Transformative Teaching (CRTT) Model in Science Learning then continued to increase to 28 publications in 2024. This increase shows that the CRTT approach is getting more attention and relevance in the realm of science education, especially in efforts to bridge the cultural diversity of students with inclusive and transformative learning practices.

The increase in the number of publications began to be evident from 2020, with a significant spike occurring between 2022 and 2024. This can be interpreted as a response from the scientific community to the urgent need to integrate local cultural contexts into the learning process, along with the increasing awareness of the importance of equitable and sustainable education.

In 2025 the graph shows a decrease in the number of publications to 8, it should be noted that the data does not cover the entire year, because it was taken until mid-year (June 2025). Thus, this figure is temporary and will likely increase until the end of the year.

Overall, these trends reflect the growing interest and attention of researchers towards the implementation of CRTT in science education, which not only enriches academic studies, but also contributes to creating learning strategies that are more relevant to the social and cultural contexts of learners.

Table 1. Trends in Culturally Responsive Transformative Teaching (CRTT) Models in Science Learning

No	*Publication Type*	*Publication*
1	*Article*	55
2	*Edited Book*	15
3	*Chapter*	3
4	*Proceeding*	3
5	*Monograph*	2

Table 1 shows the distribution of publication types discussing the Culturally Responsive Transformative Teaching

(CRTT) model in the context of science learning during the period 2016 to 2025. Of the total publications, the type of scientific articles dominates with a total of 55 publications. This indicates that journal articles are the form of research dissemination most widely used by researchers to convey studies on the CRTT model.

Next, the edited book type is in second place with 15 publications, reflecting a collective interest in compiling comprehensive theoretical and practical references on this approach. Meanwhile, publications in the form of book chapters and proceedings each number 3, and monographs as many as 2 publications. This number shows that although CRTT has become part of a broader study in education, its presentation in the form of seminar proceedings and monographs is still limited. This can be an opportunity for further researchers to develop CRTT literature in alternative formats.

Table 2. Top 10 Source Title Trends on Culturally Responsive Transformative Teaching (CRTT) model in science learning in 2016-2025

Name	***Publication***	***Citations***	***Citations mean***
Education	50	132	2.64
Curriculum and Pedagogy	45	125	2.78
Education Systems	21	39	1.86
Language, Communication and Culture	10	127	12.70
Information and Computing Scene	6	18	3.00
Psychology	5	37	7.40
Linguistics	5	112	22.40
Language Studies	4	111	25.25
Engineering	2	13	1.50
Human Society	2	9	4.50

Table 2 lists the top ten sources or disciplines that contributed the most publications on the CRTT model in science learning during 2016–2025. The Education field ranks first with 50 publications and 132 citations, with an average of 2.64 citations per publication. This confirms that CRTT is a highly relevant topic in the general education discourse.

*Curriculum and Pedagogy*also occupies a large portion with 45 publications and 125 citations, and an average citation of 2.78. This shows that the application of CRTT is widely studied in the context of developing culturally responsive curriculum and pedagogical strategies. Other disciplines such as Education Systems (21 publications), Language, Communication and Culture (10 publications), and Psychology (5 publications) also show a strong connection to the cultural, cognitive, and communication aspects of CRTT-based learning.

Interestingly, some fields such as Linguistics and Language Studies, although only contributing 5 and 4 publications, each produced a very high average citation, namely 22.40 and 25.25. This shows that the topic of CRTT in language studies is very relevant and has a high impact, especially in

discussing issues of cultural representation, use of language of instruction, and contextual learning approaches.

Meanwhile, contributions from the Engineering and Human Society fields are still relatively small (only 2 publications each), but still show the existence of developing cross-disciplinary relationships.

Table 3. Trend Keywords Culturally Responsive Transformative Teaching (CRTT) Model in Science Learning 2016-2025

Terms	*Occurrences*	*Relevance*
Culturally Responsive Teaching	9	1.40
CRT	11	1.29
Integration	8	0.95
High School	11	0.85
Science	17	0.74
PBL	6	0.70
Evaluation	7	0.63
Research Method	9	0.58
Local Wisdom	11	0.51
Implementation	14	0.51

Table 3 shows that research on the Culturally Responsive Transformative Teaching (CRTT) model in science learning in 2016–2025 highlights the application of cultural concepts in education. The word "Science" appears most frequently, indicating a primary focus on the science context. The terms "Culturally Responsive Teaching" and "CRT" have high relevance, indicating the importance of a culture-based approach. "Implementation" and "Local Wisdom" also appear frequently, indicating attention to field practice and the integration of local wisdom. Much of the research is conducted at the high school level and is combined with other approaches such as PBL. In addition, aspects of evaluation and research methods also receive significant attention.

Based on the analysis of keywords in the research of the Culturally Responsive Transformative Teaching (CRTT) model in science learning in 2016–2025, it can be concluded that research in this field shows a strong tendency towards topics such as the implementation of CRTT in science classes, especially at the high school level. The term “Culturally Responsive Teaching” and its abbreviation “CRT” appear with high frequency and relevance, indicating that a culture-based approach is a major concern in the development of learning strategies. In addition, integration with other learning methods such as Problem-Based Learning (PBL), as well as attention to evaluation and research methods, indicate efforts to increase the effectiveness and scientificity of CRTT implementation. The involvement of the “Local Wisdom” aspect also shows that local cultural values are an important element in encouraging more contextual and relevant education for students.

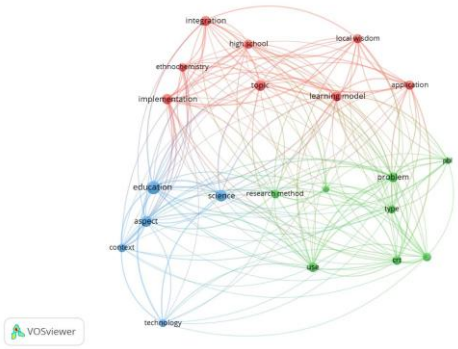

Figure 2. Visualization of Tendency Network of Culturally Responsive Transformative Teaching (CRTT) Model in Science Learning.

Figure 2 displays a visualization of the network of interrelationships between

keywords that frequently appear in studies related to the Culturally Responsive Transformative Teaching (CRTT) model in science learning during 2016–2025. This network shows how key concepts are interconnected and form thematic clusters in the research literature.

In the visualization, terms such as “Science,” “Culturally Responsive Teaching,” and “CRT” appear to be the main nodes that have many connections to other keywords, indicating that these terms are the focus of attention in various studies. The strong relationship between “CRT,” “Implementation,” and “Local Wisdom” indicates that many studies highlight the implementation of locally relevant culturally-based learning approaches.

In addition, there is also a close relationship between "Integration", "PBL", and "Evaluation", indicating that the CRTT model is often integrated with active learning approaches such as Problem-Based Learning and evaluated systematically. The word "High School" as a fairly prominent node shows that most of the studies were conducted at the high school level, strengthening the findings of the previous keyword analysis.

Overall, this network illustrates that CRTT research in science learning does not stand alone, but is closely integrated with local contexts, innovative pedagogical approaches, and evaluation frameworks that support inclusive and culturally responsive learning transformations.

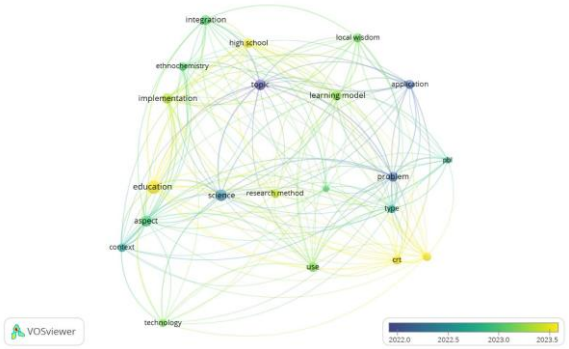

Figure 3. Overlay Visualization of Culturally Responsive Transformative Teaching (CRTT) Model Tendencies in Science Learning.

Figure 3 shows the development of keyword trends in the Culturally Responsive Transformative Teaching (CRTT) model research in science learning from 2016 to 2025. This overlay visualization uses color to indicate the average time of emergence: dark blue (around 2022) marks keywords that appeared earlier, while light yellow (2023.5) indicates keywords that appeared later.

Keywords such as “science”, “problem”, “application”, and “PBL” emerged in the early years (2022), indicating that research at that time focused more on introducing the CRTT concept in the context of science learning. Furthermore, the terms “integration”, “local wisdom”, and “ethnochemistry” emerged around 2022.5–2023, indicating the beginning of the development of CRTT integration with local wisdom and cross-disciplinary approaches.

Meanwhile, terms such as “CRT”, “education”, “use”, “implementation”, and “research method” appear more dominantly in 2023 to 2023.5, in bright yellow. This indicates a shift in research trends towards practical application, utilization of technology, and attention to evaluation and methodology of CRTT model implementation in the field.

Overall, this visualization suggests that CRTT research in science learning is evolving from a conceptual focus to more

contextual, collaborative, and locally based applications over time.

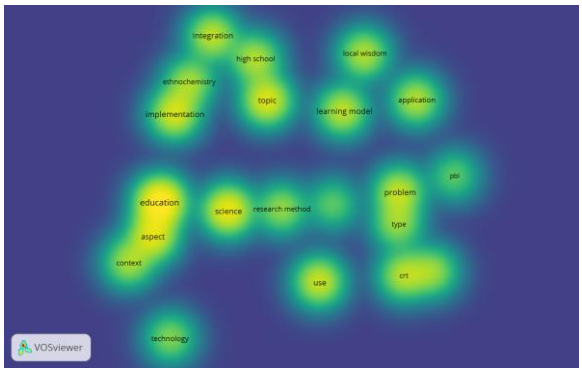

Figure 4. Visualization of Density Tendency of Culturally Responsive Transformative Teaching (CRTT) Model in Science Learning.

Figure 4 shows the density of keywords in the research on the Culturally Responsive Transformative Teaching (CRTT) model in science learning. Keywords such as education, science, and implementation appear the most dense (bright yellow), indicating that the main focus of the research is on the educational aspect, the context of science, and the application of the CRTT model. Words such as local wisdom, integration, and learning model have medium density (green), indicating that integration with local wisdom and innovative learning approaches are starting to be widely studied. Meanwhile, keywords such as technology, ethnochemistry, and PBL are in the low density area (blue), indicating that there are still open research opportunities in these fields. This visualization indicates that although CRTT research has developed, there is still a lot of room for development on topics that are contextual and transdisciplinary.

Overall, the results of the study show that the research trend on the Culturally Responsive Transformative Teaching (CRTT) model in science learning has increased significantly from year to year, especially since 2020 and peaked in 2024.

The focus of the research is mostly on implementation practices at the high school level, integration with local wisdom, and strengthening the evaluation and methodological dimensions. Network, overlay, and density visualizations confirm that CRTT has evolved from a mere concept to a transformative practice that is contextual, culturally responsive, and based on an active learning approach. This study also reveals that there is still a lot of room to develop CRTT research in the context of technology, ethnochemistry, and other cross-disciplinary approaches.

CONCLUSION AND SUGGESTION

This systematic review shows a significant increase in research related to the Culturally Responsive Transformative Teaching (CRTT) model in science learning during the period 2016 to 2025. The increasing trend of publications, especially from 2020 to its peak in 2024, reflects the increasing awareness of the importance of integrating cultural diversity and local wisdom in science learning practices. CRTT is presented as a powerful pedagogical approach to bridge students' cultural identities with science content, so that learning becomes more inclusive, contextual, and meaningful.

The results of the study show that the main focus of CRTT research is on implementation at the high school level, integration with local wisdom and active approaches such as Problem-Based Learning (PBL), and strengthening the dimensions of methodology and evaluation. Keyword analysis and network visualization strengthen the findings that CRTT research has evolved from the theoretical realm to applied practice, with transformative potential in supporting equitable and culturally relevant education.

Further research is recommended to examine areas that are still underrepresented, such as technology integration, ethnoscience, and cross-disciplinary approaches. Strengthening empirical evidence and

expanding the context of implementation are also important steps to realize the full potential of CRTT in transforming science learning to be more culturally responsive and socially just.

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AUTHOR CONTRIBUTIONS

Conceptualization, J, R; methodology, J, R; validation, JR; formal analysis, A, M; investigation, D, A; resources, D, A; data curation, GH: writing—original draft preparation, AM; writing—review and editing, J. R; visualization, A, M and All authors have read and approved the published version of the manuscript.

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