JPPIPA 10(12) (2024)

Jurnal Penelitian Pendidikan IPA

*Journal of Research in Science Education*

http://jppipa.unram.ac.id/index.php/jppipa/index

# Critical Thinking in Science Learning Research Tren From 2014-2024: A Systematic Literature Review

Irfan Akbar[1], Sulistyo Saputro[2*], Mohammad Masykuri[2]

[1] Master of Science Education, Sebelas Maret University, Surakarta, Indonesia.
[2] Department of Chemistry Education, Sebelas Maret University, Surakarta, Indonesia.

Received: August 20, 2024
Revised: November 21, 2024
Accepted: December 25, 2024
Published: December 31, 202

Corresponding Author:
Sulistyo Saputro
sulistyo_s@staff.uns.ac.id

DOI: 10.29303/jppipa.v10i12.8892



**Abstract:** Critical thinking involves identifying a problem by drawing on experience from past issues, finding relationships between these issues, and solving them in different contexts. This study aims to analyze research trends on critical thinking in science learning from 2014 to 2024. The research method is descriptive and analytical, using the PRISMA research procedure. The data comprises articles from the Scopus and Google Scholar databases, accessed with the help of Publish or Perish (PoP) software. The analyzed data includes publication year, author density, journal density, and highly cited articles. Data analysis is conducted using bibliometric analysis, supported by VOSViewer software. The findings indicate a positive trend in publications from 2014 to 2024, with slight fluctuations before a significant decline after 2021. *Wilujeng* is identified as the most prolific author, while the *Journal of Physics: Conference Series* is the journal with the most articles published on this topic. The article by Blair, Clancy published in 2014 holds the highest citation count, with 300 citations. Over the past decade, Indonesia has dominated publications in this area, accounting for 74.55% of the total.

**Keywords:** Critical Thinking; Science learning; Systematic literature review

## Introduction

The development of the 21st century is marked by massive technological advancements that have brought changes to various aspects of life. These changes have created a demand for individuals to continuously improve their skills to remain competitive. Education is one area that has undergone significant transformation. 21st-century learning emphasizes helping students hone their abilities to keep growing and stay relevant to modern needs through specific essential skills (Kaufman, 2013; van Laar et al., 2020). These skills, often called the "4Cs" of 21st-century skills, include Communication, Collaboration, Critical Thinking, and Creativity (Fuldiaratman & Ekaputra, 2023; Rudianto et al., 2022; Weng et al., 2022).

21st-century skills encourage students to continually create new ideas, evaluate and analyze acquired knowledge, and then apply and reflect on this knowledge in real life, making it a learning experience. These skills equip students with the ability to compete and become competent individuals, emphasizing the development of habitual thinking patterns (Chen & Huang, 2017; Febriya et al., 2023). Additionally, 21st-century skills help students develop effective communication, teamwork, creativity and innovation across various fields, and critical thinking.

Critical thinking is a form of higher-order, reflective, and rational thought, enabling students to identify problems using experience from previous issues, find relationships between problems, and resolve them in different contexts (Goodsett, 2020; Khairina et al., 2023; Silviariza et al., 2021). Mastering critical

**How to Cite:**
Akbar, I., Saputro, S., & Masykuri, M. (2024). Critical Thinking in Science Learning Research Tren From 2014-2024: A Systematic Literature Review. *Jurnal Penelitian Pendidikan IPA*, *10*(12), 1049–1059. https://doi.org/10.29303/jppipa.v10i12.8892

thinking skills is essential for students, as it enhances their sensitivity to problems, helping them sift through information effectively to solve the issues they encounter. Critical thinking skills can be observed in students' ability to express opinions, evaluate personal viewpoints, and their foundational drive to seek understanding and draw conclusions.

Critical thinking is particularly important in science education, as science not only emphasizes an understanding of facts, concepts, principles, and theories but also promotes the discovery of new knowledge through scientific products, processes, and attitudes (Chiappetta & Koballa, 2010; Larimore, 2020; Rizki et al., 2021). Science learning encourages and inspires students to think critically, analytically, and accurately in identifying, understanding, solving problems, and applying learning material (Anggraeni et al., 2023; Elmouhtarim, 2018; Kartini et al., 2019).

Current conditions in the field show that students' critical thinking skills remain relatively low (Ali et al., 2023; Asrowi et al., 2025; Selviyana et al., 2022). Research Nofianti et al. (2022) indicates that middle school students' critical thinking skills are generally low, with an average percentage of 43.46%. Specific dimensions are as follows: interpreting at 34.66% (very low), analyzing at 38.66% (low), evaluating at 55.33% (moderate), concluding at 29.99% (very low), and explaining at 58.66% (moderate). The low level of students' critical thinking skills is influenced by several factors, including teacher-centered learning, which limits students' exposure to active learning that maximizes critical thinking potential. Further research is needed to empower students' critical thinking skills.

Before carrying out research, it is necessary to analyze information regarding the trend of critical thinking in science learning, so it is necessary to carry out literature review research related to research trends in critical thinking in science learning in order to obtain an overview of trends and publication opportunities in the future. This research is crucial as studies on critical thinking in science education still offer potential for further exploration at the middle school, high school, and college levels (Akramova, 2017; Putri et al., 2024; Raj et al., 2022).

This study focuses on analyzing information regarding research on critical thinking within science education. A systematic literature review in this study is important to provide a comprehensive and accurate picture of how critical thinking research in science education is conducted, serving as a reference for future studies (Cavas, 2015; Dewi et al., 2024; Susetyarini & Fauzi, 2020). This research will answer questions regarding which authors are most active in critical thinking research in science learning, which journals actively publish articles related to this field, and which subtopics are most frequently discussed in critical thinking in science learning.

## Method

This research is a literature review using the PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis) method which was carried out systematically by following the research stages or protocols that have been developed (Fauza et al., 2023; Liberati et al., 2009; McInnes et al., 2018). This research follows stages which include Research question, conducting systematic literature review, searching literature and Included (Dewi et al., 2024; Haddaway et al., 2018; Onofre et al., 2021) as in Figure 1.

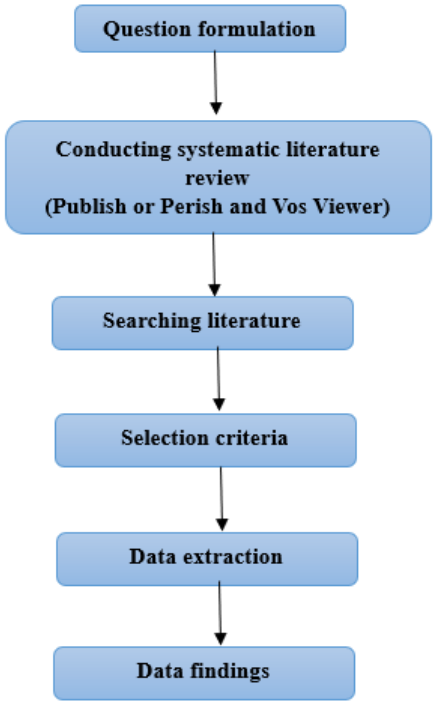


**Figure 1**. Prisma Systematic Literature Review Models

A qualitative approach is used in data analysis and provides answers to the research questions that have been formulated. After in-depth analysis, several main articles were selected to formulate research questions related to critical thinking in science learning from various perspectives from different authors.

*Formulating the research question*

The first step that must be taken is to determine the scope to be researched so that the research focus becomes clear. This research formulates several research questions which function as parameters. Research questions are presented in Table 1.

**Table 1.** Research Question

| ID | Research Question |
|---|---|
| RQ 1 | What are the trends in annual publications in the field of critical thinking in learning in the period 2014-2024? |
| RQ 2 | What is the distribution of articles containing the word critical thinking in the title published in the 2014-2024 period? |
| RQ 3 | What journal published the most articles related to critical thinking in science learning in the 2014-2024 period? |
| RQ 4 | Who are the authors most active in critical thinking research in science learning in the 2014-2024 period? |
| RQ 5 | What subtopics are most published in critical thinking research trends in the 2014-2024 period? |
| RQ 6 | What articles were most cited and published in academic journals in the 2014-2024 period? |
| RQ 7 | Which country contributed the most to the publication of articles on critical thinking in the field of science education in the period 2014-2024? |

*Conducting systematic literature review*

Next, a search was conducted using the Scopus and Google Scholar databases with the Publish or Perish (PoP) application. PoP is an application used to search and analyze reference sources needed to create scholarly works from databases such as Google Scholar, Scopus, Web of Science, Microsoft Academic, PubMed, and CrossRef (Mokhtari et al., 2020; Mondal & Mondal, 2022).

Bibliometric analysis was also applied in this study to measure the quantity and quality of published scientific research, map published articles, and trace trends in knowledge development within specific fields (Shabira et al., 2024; Singh et al., 2021; Valérie & Pierre, 2010). The bibliometric analysis in this study involved five research stages: keyword investigation; initial search refinement; total initial search reduction; initial statistical data compilation; and data interpretation through an analytical narrative (Dewi et al., 2021; Donthu et al., 2021). This bibliometric analysis focused on articles published in journals and proceedings.

The article data obtained from the search using PoP was then organized using Mendeley. VOSviewer was used to visualize data on publications on specific topics, enabling a systematic and detailed literature analysis (Arruda et al., 2022; Gunawan et al., 2022).

*Searching for literature*

This research was conducted from June to August 2024. Articles were searched using the keyword "critical thinking in science learning." The article databases used in this study were Scopus and Google Scholar. Some manual adjustments were made to maintain article consistency and minimize potential research bias.

*Selection criteria*

The articles included in this study met the following inclusion criteria: focused on issues related to critical thinking in science learning, written in English, published between 2014 and 2024, and indexed in Scopus. After the articles were gathered, an analysis was performed to ensure relevance. Descriptive qualitative analysis and synthesis were conducted to observe, describe, classify, and synthesize new insights gained through meta-synthesis.

*Data Extraction*

The research theme guided data extraction to answer the research questions. Qualitative analysis was employed to interpret and synthesize findings to address the research questions. The article extraction flowchart is shown in Figure 2.

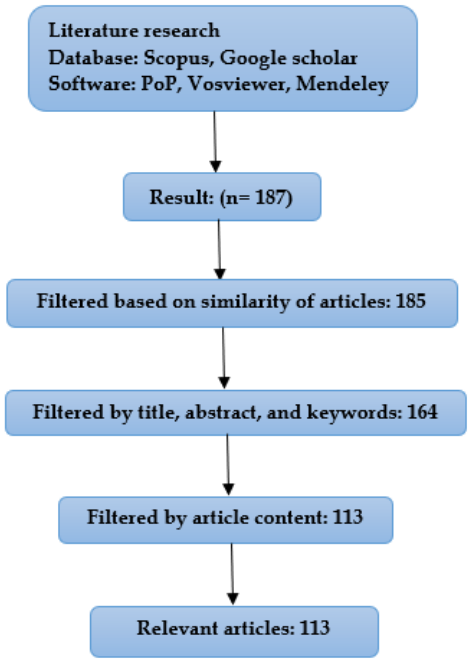


**Figure 2.** The article extraction flowchart

## Result and Discussion

Based on the search using the Publish or Perish software, a total of 187 articles were retrieved from the Scopus and Google Scholar databases. Two articles were removed due to duplication, leaving 185 articles. After removing duplicates, an additional 21 articles were excluded for not being in English or not aligning with the focus issue, resulting in 164 articles. A thorough analysis was then conducted, further narrowing the selection to 113 articles that were deemed most relevant and met the criteria.

The findings of this research are presented in seven sections: the distribution of publications on critical thinking in science learning over the 2014–2024 period, the distribution of articles containing "critical thinking" in the title, the most frequently appearing researchers, the most cited articles, the journals that most frequently publish research on critical thinking in science learning, the countries most productive in publishing on critical thinking in science learning, and the most frequently researched topics.

*Distribution of critical thinking in science learning publications during the 2014-2024 period by year*

The search results in the Scopus and Google Scholar databases found 113 articles based on titles, abstracts, keywords, and summaries containing the words "critical thinking". Figure 2 illustrates the distribution of publications on critical thinking in science learning from January 2014 to August 2024, based on the annual research volume, to answer the first research question.

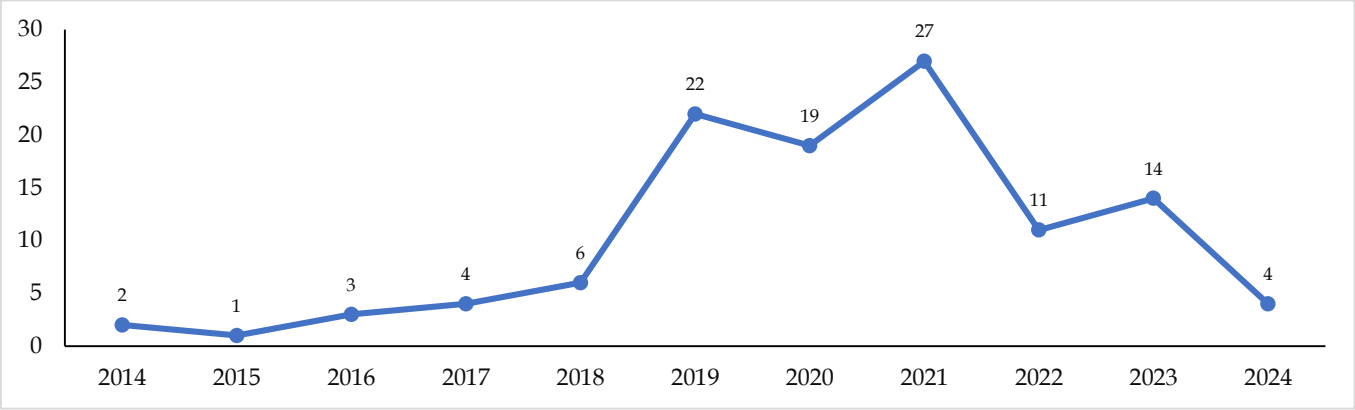


**Figure 3**. Distribution of Publications by Year

The analysis results show that the publication trend of critical thinking in science learning is fluctuating. From 2014 to 2018, there was a gradual increase with slight fluctuations. In 2015, there was a decline from 2014 before rising again in 2016. The year 2015 had the fewest publications, with only one article. A significant increase occurred in 2019, continuing to its peak in 2021. The peak of critical thinking in science learning research publications occurred in 2021, with a total of 27 papers published. After reaching the peak in 2021, there was a decline until 2022. Although there was a slight increase in 2023, the number of publications dropped significantly again in 2024. The sharp decline in 2024 was due to the data being collected up to August, with four months remaining in 2024. The declining trend in critical thinking in science learning research from 2022 to 2024 highlights the need for further research in this area, considering that critical thinking is an essential skill for students, especially in science education (Sumarni & Kadarwati, 2020; Zulyusri et al., 2023).

*Distribution of critical thinking in science learning publications during the 2014-2024 period which contains critical thinking in the title*

The distribution of articles, whether they include "critical thinking" in the title or not, during the period from 2014 to 2024 to answer the second research question can be seen in Figure 4.

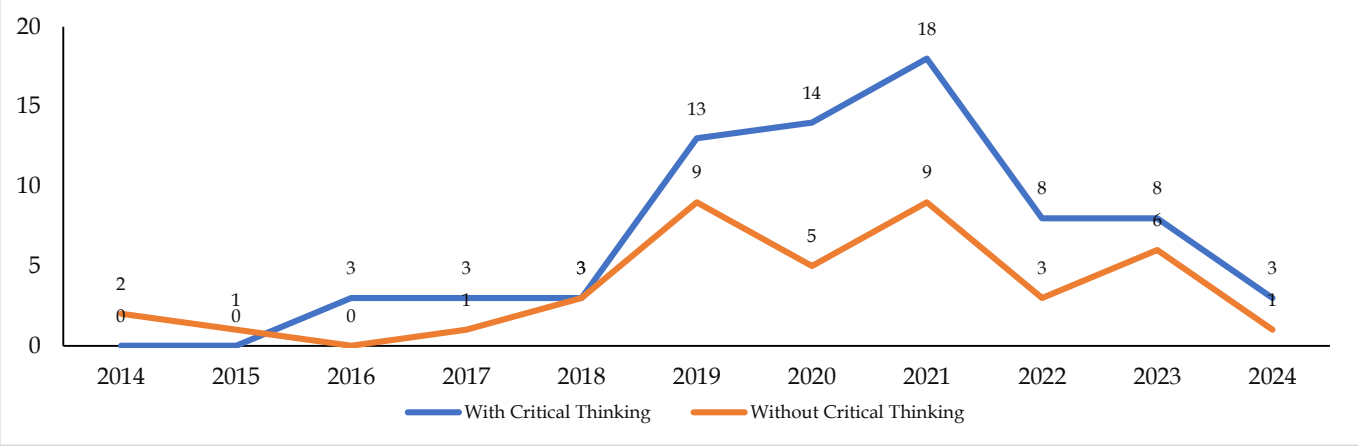


**Figure 4.** Distribution of the Word "Critical Thinking" in Titles

The analysis results show that the distribution of articles is quite fluctuating. The number of articles with "critical thinking" in their titles is 73, while 40 articles do not include "critical thinking" in their titles. Articles containing "critical thinking" in the title show a more positive trend, with a significant increase from 2014, reaching a peak in 2021 before declining until 2024. The distribution of articles without "critical thinking" in the title is also quite fluctuating. From 2014 to 2016, there was a significant decline, with 2016 being a year with no publications at all, before a gradual increase until 2019. After 2019, the number of articles alternated between increases and decreases each year, eventually declining again in 2024.

*Number of publications by journal*

The results of the analysis of the academic journals with the most published papers during the period 2014-2024 to answer the fourth research question are presented in Table 2.

**Tabel 2.** Most Published Journal

| Rank | Journal | N of Papers |
|---|---|---|
| 1 | Journal of Physics Conference Series | 43 |
| 2 | ACM International Conference Proceeding Series | 4 |
| 2 | Jurnal Pendidikan IPA Indonesia | 4 |
| 2 | International Journal of Emerging Technologies in Learning | 3 |
| 3 | International Journal of Instruction | 3 |
| 3 | International Journal of Interactive Mobile Technologies | 3 |
| 4 | International Journal of Learning, Teaching and Educational Research | 3 |
| 4 | Thinking Skills and Creativity | 3 |
| 5 | Cakrawala Pendidikan | 2 |
| 5 | Computer and Education | 2 |

Based on Table 2 above, it is known that 10 journals published the most papers on critical thinking in science learning during the 2014-2024 period. Critical thinking in science learning research is most widely published in the Journal of Physics Conference Series with a total of 43 papers. Furthermore, the ACM International Conference Proceedings Series and the Indonesian Science Education Journal are in second place with a total of 4 papers each, followed by several other journals with an average number of 3-2 papers.

*Density of researchers in the field of critical thinking in science learning*

Research in the field of critical thinking in science learning has increasingly been conducted since 2014. Therefore, to answer the third research question, an analysis was carried out to determine which researchers have published the most articles on this topic, providing a reference for future studies. The visualization of the researchers who have published the most on critical thinking in science learning was done using the VOSViewer application. The results of the visualization are shown in Figure 5.

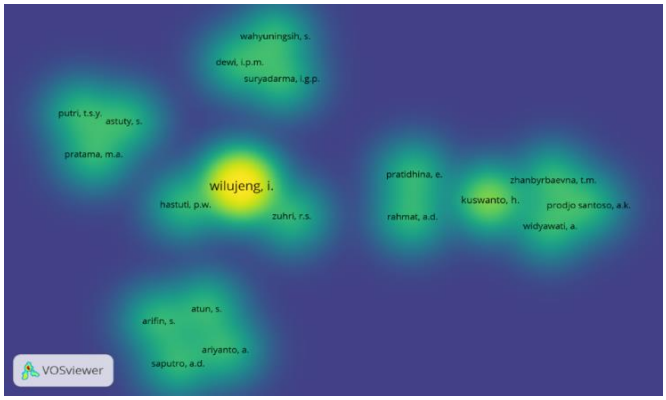


**Figure 5**. Researchers who published the most critical thinking in science learning

Figure 5 above shows a density visualization of researchers in the field of critical thinking in science learning. The researcher density is represented by bright yellow areas; the brighter the yellow, the more articles on critical thinking in science learning have been published by that researcher. Conversely, dimmer yellow areas indicate fewer articles published on the topic (Doyan et al., 2024; Kaur et al., 2022).

Overall, the visualization reveals 19 researchers identified under the search subject "critical thinking in science learning." The findings indicate that research on critical thinking in science learning is predominantly conducted by researchers from Indonesia. Among these, Wilujeng, I. stands out with the brightest yellow indicator, signifying that Wilujeng, I. is the most prolific researcher in this field, having published six articles on critical thinking in science learning. These publications by Wilujeng, I. can serve as a valuable reference for future research on this topic. The other 18 researchers have published at similar frequencies, ranging from three to one article each.

*The most frequently researched research topics in the field of critical thinking in science learning*

Research sub-topic density analysis was carried out to answer the seventh research question by identifying the research topics that most frequently appear in critical thinking in science learning research. Visualization of research subtopics that often appear related to critical thinking in science learning that often appear during the 2014-2024 time period is carried out using the VOSViewer application. The visualization results are shown in Figure 6.

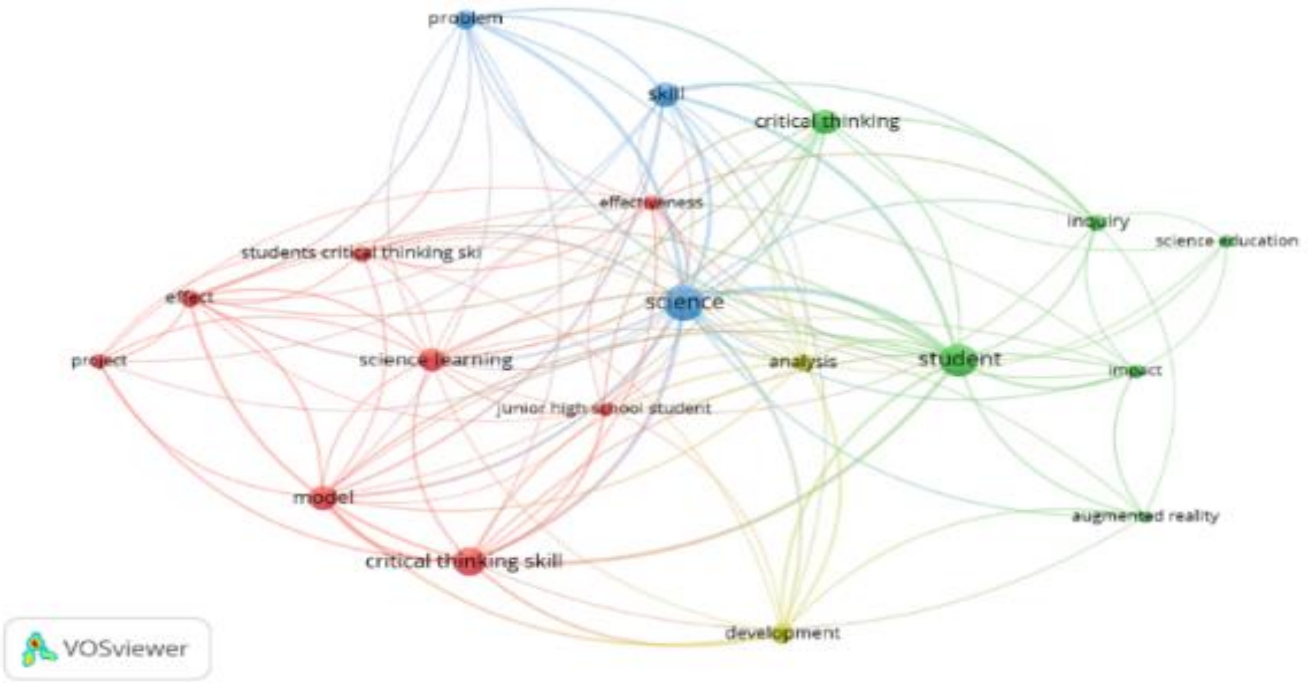


**Figure 6**. The Most Frequently Researched Research Topics in The Field of Critical Thinking in Science Learning

Based on Figure 6, the research subtopic in the shape of a large blue ball is the most researched subtopic, while the subtopic in the shape of a smaller ball is the least discussed subtopic. The subtopics that are most often discussed the least can become reference topics in subsequent research.

*Distribution of the most cited articles*

The fifth research question regarding the most cited articles is analyzed in Table 3.

**Tabel 3.** Most Cited Papers in Critical Thinking Research Between 2014-2024

| Rank | Cites | Authors | Years | Title |
|---|---|---|---|---|
| 1 | 300 | Blair, Calncy | 2014 | Closing the achievement gap through modification of neurocognitive and neuroendocrine function: Results from a cluster randomized controlled trial of an innovative approach to the education of children in kindergarten |
| 2 | 239 | Chang, Sao-Chen | 2018 | Impacts of an augmented reality-based flipped learning guiding approach on students' scientific project performance and perceptions |
| 3 | 99 | Mahmood H. Hussein, Siew Hock Ow, Loh Sau Cheong, Meow-Keong Thong, & Nader Ale Ebrahim | 2019 | Effects of Digital Game-Based Learning on Elementary Science Learning: A Systematic Review |
| 4 | 94 | Vieira, Rui Marques | 2016 | Fostering Scientific Literacy and Critical Thinking in Elementary Science Education |
| 5 | 65 | Ahmad Syawaludin, Gunarhadi, & Peduk Rintayani | 2019 | Development of augmented reality-based interactive multimedia to improve critical thinking skills in science learning |
| 6 | 63 | Bathgate, Meghan., Crowell, Amanda., Schunn, Christian., Cannady, Mac., & Dorph, rena | 2015 | The Learning Benefits of Being Willing and Able to Engage in Scientific Argumentation |
| 7 | 50 | Sutiani, Ani,, Situmorang, Manihar, & Silalahi, Albinus | 2021 | Using educational data mining to assess students' skills at designing and conducting experiments within a complex systems microworld |

| Rank | Cites | Authors | Years | Title |
|---|---|---|---|---|
| 8 | 45 | Mahmood H. Hussein, Siew Hock Ow, Loh Sau Cheong, & Meow-Keong Thong | 2019 | A Digital Game-Based Learning Method to Improve Students' Critical Thinking Skills in Elementary Science |
| 9 | 43 | Hand, Brian., Shelley, Mack C., Lauugerman, Marcia., Fostvedt, Luke., & Therrien, William | 2018 | Improving critical thinking growth for disadvantaged groups within elementary school science: A randomized controlled trial using the Science Writing Heuristic approach |
| 10 | 40 | Rossi, Izadora Volpato., de Lima, Jordana Dinora., Sabatke, Bruna., Nunes, Maria Alice Ferreira., Ramirez, Graciela Evans., & Ramirez, Marcel Ivan | 2021 | Active learning tools improve the learning outcomes, scientific attitude, and critical thinking in higher education: Experiences in an online course during the COVID-19 pandemic |

Table 3 depicts the 10 most cited papers in the 2014-2024 time period. Papers are sorted by the highest number of citations. The number of citations was obtained from the Scopus database assisted by the Publish or Perish application. The results of the analysis show that Blair, Calncy's article, published in 2014, is the most cited article with 300 citations. This is followed by Chang, Sao-Chen's article, published in 2018, with 239 citations, and the author's articles others with less than 100 citations.

*The most productive country in critical thinking research.*

This analysis aims to identify which countries are most active in publications in the field of critical thinking in science learning based on the sixth research question. The results of the analysis of countries with the highest number of paper publications in the field of critical thinking in science learning in the 2014-2024 period are presented in Table 4.

**Tabel 4**. Rank of Publication by Country

| Rank | Country | N of Papers | Percentage (%) |
|---|---|---|---|
| 1 | Indonesia | 82 | 74.55 |
| 2 | United States | 11 | 10.00 |
| 3 | Malaysia | 5 | 4.55 |
| 4 | Taiwan | 3 | 2.73 |
| 5 | China | 2 | 1.82 |
| 6 | Colombia | 2 | 1.82 |
| 7 | Japan | 2 | 1.82 |

Based on Table 4, it is known that the countries with the highest publication productivity in the field of critical thinking in science learning are dominated by Indonesia with a total of 82 papers (74.55%), followed by the US with 11 papers (10%), Malaysia with 5 papers (4 .55%), Taiwan 3 papers (2.73%) and other countries with percentages below 2%.

This study provides a comprehensive overview through a systematic literature review, offering broad and relevant insights into publications in the field of critical thinking in science learning. The results show that the distribution of articles published from 2014 to 2024 has been quite fluctuating. A significant increase occurred between 2014 and 2021 with slight fluctuations, but after 2021, the trend of publications on critical thinking in science learning continued to decline. This is a serious concern, considering that critical thinking is one of the 21st-century skills that students must possess (Kereluik et al., 2013; Sarıgöz, 2023). If this continues, there will be a significant decline year after year.

The second research question regarding the distribution of articles that contain or do not contain critical thinking in the title varied from the beginning of 2014 to the end of 2024. The number of articles that included critical thinking in the title was 73, while the remaining 40 articles did not include critical thinking in the title. Regardless of whether the title contained critical thinking or not, the trend of critical thinking in science learning research had a positive trend, as evidenced by a significant increase from 2014 to 2021, despite slight fluctuations in some years, before eventually continuing to decline in subsequent years.

In terms of journal publication productivity, the Journal of Physics Conference Series was the most productive in publishing articles on critical thinking research, with a total of 43 articles. The Journal of Physics Conference Series likely became the most productive journal in publishing critical thinking research because many researchers in Indonesia submitted their articles to international conferences indexed by Scopus and then published them in the Journal of Physics Conference Series. Besides the Journal of Physics Conference Series, ACM International Conference Proceeding Series and Jurnal Pendidikan IPA Indonesia were also highly productive in publishing articles on critical thinking in science learning, each with four articles. Jurnal Pendidikan IPA Indonesia provides four publications per year. Additionally, Jurnal Pendidikan IPA Indonesia collaborates with the Indonesian Society for Science Educators, which has attracted the attention of researchers in the field of critical thinking in science learning in recent years.

The fourth research question regarding the most active authors in critical thinking research revealed that Wilujeng is the most productive author. Visualization using the VOS Viewer application showed that Wilujeng stood out the most compared to other authors.

The fifth research question regarding the density of subtopics studied in science learning, the findings of this study can serve as a reference for future research to explore areas that are still under-researched. The empowerment of critical thinking in science learning can utilize learning models such as problem-based learning, discovery learning, inquiry learning, and others. The use of media is also recommended in empowering critical thinking, such as modules, applications, virtual reality, and others. Additionally, critical thinking in science learning research still has opportunities to be further explored with subjects ranging from middle school, and high school, to university students.

Regarding the most cited article found that Blair and Calncy's article, published in 2014, was the most cited, with 300 citations. According to the graph on annual publication trends, only two articles on critical thinking were published in 2014. This indicates that the article was a primary or pioneering article, which led to it being frequently cited by other researchers in subsequent years. The next most cited article was by Chang and Sao-Chen, published in 2018, with 239 citations.

Regarding the countries with high productivity in the field of critical thinking research, it was found that Indonesia is the most productive country in conducting critical thinking in science learning research, followed by the United States and Malaysia in third place. The development of 21st-century learning, which emphasizes mastery of critical thinking skills as one of the 21st-century skills that students must possess, has driven the intensity of critical thinking in science learning publications in Indonesia.

## Conclusion

The conclusion based on a review of 113 articles on critical thinking in science learning published between 2014 and 2024 shows that the publication trend has increased positively with slight fluctuations before ultimately experiencing a decline. The highest number of publications, both mentioning critical thinking in the title and not, occurred in 2021. The most productive researcher in publishing articles is Wilujeng. The journal that most frequently published critical thinking articles is the *Journal of Physics Conference Series*. The article with the most citations is Blair and Calncy's article from 2014 with 300 citations, followed by Chang and Sao-Chen's article from 2018 with 239 citations. Indonesia has dominated publications in the past decade, accounting for 74.55% of total publications. Subtopics within critical thinking in science learning research still have potential for further exploration.

**Acknowledgments**

The author would like to thank the co-authors who have helped and contributed to completing this research. The author hopes this article is useful for all parties involved.

**Author Contributions**

Systematic literature review using publish or perish and vos viewer, I. A.; writing-original draft preparation, methodology, analysis, result and discussion, S. S.; review discussion, editing and conclusion, M. M. All authors have read and agreed to the published version of the manuscript.

**Funding**

This research received no external funding.

**Conflicts of Interest**

The authors declare that there is no conflict of interest regarding the publication of this paper.

## References

Akramova, G. R. (2017). Modern Approaches to Development Critical Thinking of Students. *Eastern European Scientific Journal*, *5*(2). https://doi.org/10.12851/EESJ201610C02ART03

Ali, Rafika, Palliwi, E. D., Nuraini, & Rahmadiani. (2023). Implementing Guided Inquiry-Based Biology Learning Tools to Enhance Students' Critical Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(6), 4856–4862. https://doi.org/10.29303/jppipa.v9i6.4541

Anggraeni, D. M., Prahani, B. K., Suprapto, N., Shofiyah, N., & Jatmiko, B. (2023). Systematic review of problem based learning research in fostering critical thinking skills. *Thinking Skills and Creativity*, *49*(May), 101334. https://doi.org/10.1016/j.tsc.2023.101334

Arruda, H., Silva, E. R., Lessa, M., Proença, D., & Bartholo, R. (2022). VOSviewer and Bibliometrix. *Journal of the Medical Library Association : JMLA*, *110*(3), 392–395. https://doi.org/10.5195/jmla.2022.1434

Asrowi, Maulana, I., Budiarto, M. K., & Qodr, T. S. (2025). Assessing critical thinking skills in vocational school students during hybrid learning. *Journal of Education and Learning*, *19*(1), 232–240. https://doi.org/10.11591/edulearn.v19i1.21754

Cavas, B. (2015). Research Trends in Science Education International: A Content Analysis for The Last Five Years (2011-2015). *Science Education International*, *25*(4), 573–588. Retrieved from https://eric.ed.gov/?id=EJ1086555

Chen, B. H. S., & Huang, H. (2017). *Advancing 21st Century Competencies in Taiwan Advancing 21st*

*Century Competencies in Taiwan*. National Taiwan Normal University.

Chiappetta, E. L., & Koballa, T. R. (2010). *Science Instruction in the Middle and Secondary Schools*. Allyn & Bacon.

Dewi, A. K., Prayitno, B. A., & Mahardiani, L. (2024). Development of an Environment-Based Critical Thinking Skills Test Instrument for Class VII Middle School Science Learning. *Jurnal Penelitian Pendidikan IPA*, *10*(8), 5759–5767. https://doi.org/10.29303/jppipa.v10i8.7748

Dewi, M. R., & Arifin, Z. (2024). Analysis of 21st Century Skills in the Implementation of Project Based Learning in Biology Learning Merdeka Curriculum. *Jurnal Penelitian Pendidikan IPA*, *10*(4), 2118–2128. https://doi.org/10.29303/jppipa.v10i4.5941

Dewi, P. S., Widodo, A., Rochintaniawati, D., & Prima, E. C. (2021). Web-Based Inquiry in Science Learning: Bibliometric Analysis. *Indonesian Journal of Science and Mathematics Education*, *4*(2), 191–203. https://doi.org/10.24042/ijsme.v4i2.9576

Dewi, R. K., Dian, D., Wati, E., Lasmana, O., & Alberida, H. (2024). Development Research in Science Education : A Systematic Literature Review of Trends in Development Models and Instruments Used. *Jurnal Penelitian Pendidikan IPA*, *10*(5), 250–261. https://doi.org/10.29303/jppipa.v10i5.6876

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, *133*(March), 285–296. https://doi.org/10.1016/j.jbusres.2021.04.070

Doyan, A., Annam, S., Muliyadi, L., Rize, R., Megahati, P., Hutabarat, A., Ikhsan, M., & Ardianti, N. R. (2024). Trends Research Creative Thinking Skills in Students ' Physics Learning ( 2015-2024 ): A Systematic Review. *Jurnal Penelitian Pendidikan IPA*, *10*(6), 333–342. https://doi.org/10.29303/jppipa.v10i6.7826

Elmouhtarim, S. (2018). Integrating Critical Thinking Skills in Reading Courses at the University Level The Case of Faculty of Letters and Humanities, Beni-Mellal, Morocco. *Arab World English Journal*, *9*(3), 331–344. https://doi.org/10.24093/awej/vol9no3.22

Fauza, N., Rahim, F. R., Riwandi, F. O., Latif, A., & Mathluba, K. (2023). Microcontroller-Based Mechanics Experiments in Physics Learning : Systematic Literature Review Using PRISMA. *Jurnal Penelitian Pendidikan IPA*, *9*(9), 558–568. https://doi.org/10.29303/jppipa.v9i9.5258

Febriya, D., Festiyed, Hikmah, N., & Mufit, F. (2023). Literature Study: Application of Self Assessment in Improving Character Quality, 21st Century Abilities, and Physics Learning Results. *Jurnal Penelitian Pendidikan IPA*, *9*(12), 1370–1376. https://doi.org/10.29303/jppipa.v9i12.5219

Fuldiaratman, & Ekaputra, F. (2023). Analysis of Students' 4C Skills Based on Project Based Learning through Chemo Entrepreneurship Media. *EduLine: Journal of Education and Learning Innovation*, *3*(3), 454–459. https://doi.org/10.35877/454ri.eduline2057

Goodsett, M. (2020). Best Practices for Teaching and Assessing Critical Thinking in Information Literacy Online Learning Objects. *Journal of Academic Librarianship*, *46*(5), 1–7. https://doi.org/10.1016/j.acalib.2020.102163

Gunawan, B., Ratmono, B. M., Abdullah, A. G., Sadida, N., & Kaprisma, H. (2022). Research Mapping in the Use of Technology for Fake News Detection: Bibliometric Analysis from 2011 to 2021. *Indonesian Journal of Science and Technology*, *7*(3), 471–496. https://doi.org/10.17509/ijost.v7i3.51449

Haddaway, N. R., Macura, B., Whaley, P., & Pullin, A. S. (2018). ROSES Reporting standards for Systematic Evidence Syntheses: Pro forma, flow-diagram and descriptive summary of the plan and conduct of environmental systematic reviews and systematic maps. *Environmental Evidence*, *7*(1). https://doi.org/10.1186/s13750-018-0121-7

Kain, C., Koschmieder, C., Matischek-Jauk, M., & Bergner, S. (2024). Mapping the landscape: A scoping review of 21st century skills literature in secondary education. *Teaching and Teacher Education*, *151*(December 2023), 104739. https://doi.org/10.1016/j.tate.2024.104739

Kartini, Doyan, A., Kosim, Susilawati, Khasanah, B. U., Hakim, S., & Muliyadi, L. (2019). Analysis of Validation Development Learning Model Attainment Concept to Improve Critical Thinking Skills and Student Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, *5*(2), 185–188. https://doi.org/10.29303/jppipa.v5i2.262

Kaufman, K. J. (2013). 21 Ways to 21st Century Skills: Why Students Need Them and Ideas for Practical Implementation. *Kappa Delta Pi Record*, *49*(2), 78–83. https://doi.org/10.1080/00228958.2013.786594

Kaur, S., Kumar, R., Kaur, R., Singh, S., Rani, S., & Kaur, A. (2022). Materials Today : Proceedings Piezoelectric materials in sensors : Bibliometric and visualization analysis. *Materials Today: Proceedings*, *65*, 3780–3786. https://doi.org/10.1016/j.matpr.2022.06.484

Kereluik, K., Mishra, P., Fahnoe, C., & Terry, L. (2013). What Knowledge Is of Most Worth: Teacher Knowledge for 21st Century Learning. *Journal of Digital Learning in Teacher Education*, *29*(4), 127–140. https://doi.org/10.1080/21532974.2013.10784716

Khairina, R., Wahyuningsih, D., & Khasanah, A. N. (2023). Relationship Between Critical Thinking Skills and Metacognition Awareness with Learning Outcomes in Science Learning. *Jurnal Penelitian Pendidikan IPA*, *9*(5), 2305–2311. https://doi.org/10.29303/jppipa.v9i5.2140

Larimore, R. A. (2020). Preschool Science Education: A Vision for the Future. *Early Childhood Education Journal*, *48*(6), 703–714. https://doi.org/10.1007/s10643-020-01033-9

Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P. A., Clarke, M., Devereaux, P. J., Kleijnen, J., & Moher, D. (2009). The PRISMA Statement for Reporting Systematic Reviews and Meta-Analyses of Studies That Evaluate Health Care Interventions: Explanation and Elaboration. *Journal of Clinical Epidemiology*, *62*(10), e1–e34. https://doi.org/10.1016/j.jclinepi.2009.06.006

McInnes, M. D. F., Moher, D., Thombs, B. D., McGrath, T. A., Bossuyt, P. M., Clifford, T., Cohen, J. F., Deeks, J. J., Gatsonis, C., Hooft, L., Hunt, H. A., Hyde, C. J., Korevaar, D. A., Leeflang, M. M. G., Macaskill, P., Reitsma, J. B., Rodin, R., Rutjes, A. W. S., Salameh, J. P., … Willis, B. H. (2018). Preferred Reporting Items for a Systematic Review and Meta-analysis of Diagnostic Test Accuracy Studies The PRISMA-DTA Statement. *JAMA - Journal of the American Medical Association*, *319*(4), 388–396. https://doi.org/10.1001/jama.2017.19163

Mokhtari, H., Soltani-Nejad, N., Mirezati, S. Z., & Saberi, M. K. (2020). A Bibliometric and Altmetric Analysis of Anatolia: 1997–2018. *Anatolia*, *31*(3), 406–422. https://doi.org/10.1080/13032917.2020.1740285

Mondal, H., & Mondal, S. (2022). A Hypothesis to Stop "Publish or Perish." *Medical Journal of Dr. D.Y. Patil Vidyapeeth*, *15*(5), 809–810. https://doi.org/10.4103/mjdrdypu.mjdrdypu_110_21

Nofianti, E., Nurhidayanti, A., Handayani, N. A., Rosana, D., & Wilujeng, I. (2022). Profil Berpikir Kritis Peserta Didik SMP pada Materi Sistem Ekskresi Manusia. *Jurnal Pendidikan Sains Indonesia*, *10*(3), 479–491. https://doi.org/10.24815/jpsi.v10i3.23877

Onofre, R. S., Catalá-López, F., Aromataris, E., & Lockwood, C. (2021). How to Properly Use the PRISMA Statement. *Systematic Reviews*, *10*(1), 13–15. https://doi.org/10.1186/s13643-021-01671-z

Putri, S. E., Arthamena, V. D., Retiyanto, H. F., Shiddiqi, M. H. A., & Suyanta. (2024). Creative Thinking Skills in Chemistry Learning: A Systematic Literature Review. *Jurnal Penelitian Pendidikan IPA*, *10*(4), 158–167. https://doi.org/10.29303/jppipa.v10i4.6343

Raj, T., Chauhan, P., Mehrotra, R., & Sharma, M. (2022). Importance of Critical Thinking in the Education. *World Journal of English Language*, *12*(3), 126–133. https://doi.org/10.5430/wjel.v12n3p126

Rizki, A., Khaldun, I., & Pada, A. U. T. (2021). Development of Discovery Learning Student Worksheets to Improve Students ' Critical Thinking Skills in Chemical Balance Materials. *Jurnal Penelitian Pendidikan IPA*, *7*(4). https://doi.org/10.29303/jppipa.v7i4.829

Rudianto, Diani, R., Subandi, & Widiawati, N. (2022). Development of Assessment Instruments 4C Skills (Critical Thinking , Collaboration , Communication , and Creativity ) on Parabolic Motion Materials. *Journal of Advanced Sciences and Mathematics Education*, *2*(2), 65–79. https://doi.org/10.58524/jasme.v2i2.115

Sarıgöz, O. (2023). Teaching the 21st Century Learning Skills with the Critical Thinking Technique Based on the Argumentation Method. *Educational Policy Analysis and Strategic Research*, *18*(1), 196–218. https://doi.org/10.29329/epasr.2023.525.9

Selviyana, Yusrizal, Halim, A., Syukri, M., & Elisa. (2022). Application of Problem Based Learning (PBL) Model to Improve Problem Solving Skill from Critical Thinking Skill Students on Dynamic Fluid Materials. *Jurnal Penelitian Pendidikan IPA*, *8*(2), 521–527. https://doi.org/10.29303/jppipa.v8i2.1329

Shabira, Q., Baharudin, & Yanti, Y. (2024). Mapping the Literature of Technological Pedagogical and Content Knowledge ( TPACK ) in Elementary Education : A Bibliometric Review. *Jurnal Penelitian Pendidikan IPA*, *10*(9), 631–643. https://doi.org/10.29303/jppipa.v10i9.8731

Silviariza, W. Y., Sumarmi, & Handoyo, B. (2021). Improving Critical Thinking Skills of Geography Students With Spatial-Problem Based Learning (SPBL). *International Journal of Instruction*, *14*(3), 133–152. https://doi.org/10.29333/iji.2021.1438a

Singh, V. K., Singh, P., Karmakar, M., Leta, J., & Mayr, P. (2021). The Journal Coverage of Web of Science, Scopus and Dimensions: A Comparative Analysis. *Scientometrics*, *126*(6), 5113–5142. https://doi.org/10.1007/s11192-021-03948-5

Sumarni, W., & Kadarwati, S. (2020). Jurnal Pendidikan IPA Indonesia Ethno-STEM Project-Based Learning : Its Impact to Critical. *Jurnal Pendidikan IPA Indonesia*, *9*(1), 11–21. https://doi.org/10.15294/jpii.v9i1.21754

Susetyarini, E., & Fauzi, A. (2020). Trend of critical thinking skill researches in biology education journals across Indonesia: From research design to data analysis. *International Journal of Instruction*, *13*(1), 535–550. https://doi.org/10.29333/iji.2020.13135a

Valérie, D., & Pierre, A. G. (2010). Bibliometric idicators: Quality Masurements of Sientific Publication. *Radiology*, *255*(2), 342–351. https://doi.org/10.1148/radiol.09090626

van Laar, E., van Deursen, A. J. A. M., van Dijk, J. A. G. M., & de Haan, J. (2020). Determinants of 21st-Century Skills and 21st-Century Digital Skills for Workers: A Systematic Literature Review. *SAGE Open*, *10*(1). https://doi.org/10.1177/2158244019900176

Weng, X., Cui, Z., Ng, O. L., Jong, M. S. Y., & Chiu, T. K. F. (2022). Characterizing Students' 4C Skills Development During Problem-based Digital Making. *Journal of Science Education and Technology*, *31*(3), 372–385. https://doi.org/10.1007/s10956-022-09961-4

Zulyusri, Elfira, I., & Santosa, T. A. (2023). Literature Study : Utilization of the PjBL Model in Science Education to Improve Creativity and Critical Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(1), 133–143. https://doi.org/10.29303/jppipa.v9i1.2555