

Research Article

Critical thinking in mathematics education: A bibliometric analysis

Nuke Fitri Yanuari¹, Turmudi*²

¹ Master Program, Department of Mathematics Education, Indonesia University of Education, Bandung, 40154, Indonesia

² Department of Mathematics Education, Indonesia University of Education, Bandung, 40154, Indonesia

*Corresponding Author: turmudi@upi.edu | Phone: +6287718841525

Received: 8 June 2023

Revised: 20 May 2023

Accepted: 26 June 2023

Available online: 30 June 2023

ABSTRACT

Mathematical critical thinking is one of the most important skills that students must possess. The ability to think critically in mathematics is an essential skill that can be developed through effective teaching practices and student engagement. This article presents the questions to be investigated regarding critical thinking using bibliometric analysis. Bibliometric analysis is a method used to analyze research articles related to a chosen topic. The data source for this analysis is Scopus. The search was filtered by subject area, document type, language, and publication year. According to the results from Scopus, a total of 148 documents related to mathematical critical thinking were obtained from 2019 until May 2023. Based on the co-occurrence analysis of authors' keywords, besides 'critical thinking' and 'critical thinking skills', 'secondary school' and 'secondary education' appeared most frequently, with 6 occurrences. These trends in the number of articles can provide insights into the research interests in this field.

Keywords: critical thinking; mathematics education; bibliometric analysis;

1. INTRODUCTION

Mathematics is a subject that requires critical thinking skills to analyze and solve complex problems. Mathematical critical thinking is an important-skills that students must possess because the ability to think critically in mathematics is essential and can be developed through effective teaching practices and student engagement. Critical thinking involves reasonable, reflective thinking that is focuses on deciding making informed decisions or beliefs (Ennis, 1996). Critical thinking is the ability to think about one's own thinking to enhance the quality of thinking and make effective decisions (Scriven et al., 1987; and Judge et al., 2009). Critical thinking in mathematics, the goal could be to learn how to determine the most efficient and effective method to solve problems includes building mathematical ideas through explaining, questioning, and organizing, using mathematical understanding to generate new ideas, providing reasons or judgments, and performing ways to solve mathematical problems (Anderson & Krathwohl, 2001; and Permani & Prabawanto, 2020; Salwah et al., 2020). Mathematical critical thinking can be defined as the processes and abilities used to understand mathematical concepts, apply them, synthesize information, and evaluate the generated information (Purnamasari et al., 2021). Mathematical critical thinking skills include the ability to reason and provide clarity in mathematical statements (Rojas & Benakli, 2020). Mathematical critical thinking skills are also important to improve students' problem-solving skills and understanding of math concepts (Afriansyah et al., 2020). Numerous researchers have studied critical thinking, including (Mafarja & Zulnaidi, 2022; Utama et al., 2022; Putri et al., 2023; Assi et al., 2023; Pantiwati et al., 2023; Sinaga et al., 2022). The extensive research on critical thinking has sparked the author's interest in conducting a bibliometric analysis.

Bibliometric analysis is a method used to analyze academic publishing related to a chosen topic, utilizing statistics to describe trends (Ninkov et al., 2022). This bibliometric analysis has piqued the author's interest, prompting its utilization. This article will present the questions to be investigated regarding critical thinking using bibliometric analysis.

- How is the distribution of research publications about critical thinking based on year, sources, and document types?
- Which country has published the most research on critical thinking?
- Who is the leading author who has published the most research on critical thinking?
- What are the research interest based on the co-occurrence analysis of authors' keyword?

2. RESEARCH METHOD

Bibliometric analysis is a method used to analyzed research articles related to a specific topic. The chosen research topic focuses on mathematical critical thinking skills, and the data source for this analysis is Scopus. Scopus is an invaluable

resource for researchers, offering access to a vast collection of academic literature, including peer-reviewed journals across various subject fields such as life sciences, social sciences, and more. Utilizing Scopus, researchers can perform bibliometric analyses on studies concerning mathematical critical thinking skills. The keywords used in the Scopus search are 'Critical Thinking' AND 'Junior High School' OR 'Senior High School' OR 'Secondary School'. A total of 893 research articles were found related to critical thinking. To obtain the most relevant results, several filters were applied. Firstly, in the subject area section, only social sciences and mathematics were selected. Secondly, in the document type section, only articles and conference papers were chosen. Additionally, the language filter was set to English, and the publication year range was set from 2019 to 2023. A total of 148 documents resulted from the applied filters in the search. To export the data, select the CSV Excel format and choose to export all the relevant information. For analysis, utilize the RStudio and VOSViewer applications.

3. RESULTS AND DISCUSSION

3.1 Document by year, source and type

The keywords used in the Scopus search were 'Critical Thinking' AND 'Junior High School' OR 'Senior High School' OR 'Secondary School'. The first filter in the subject area section selects only social sciences and mathematics. In the document type section, articles and conference papers are chosen. The language filter is set to English, and the publication year range is selected as 2019 to 2023. **Figure 1** displays the search results in Scopus.

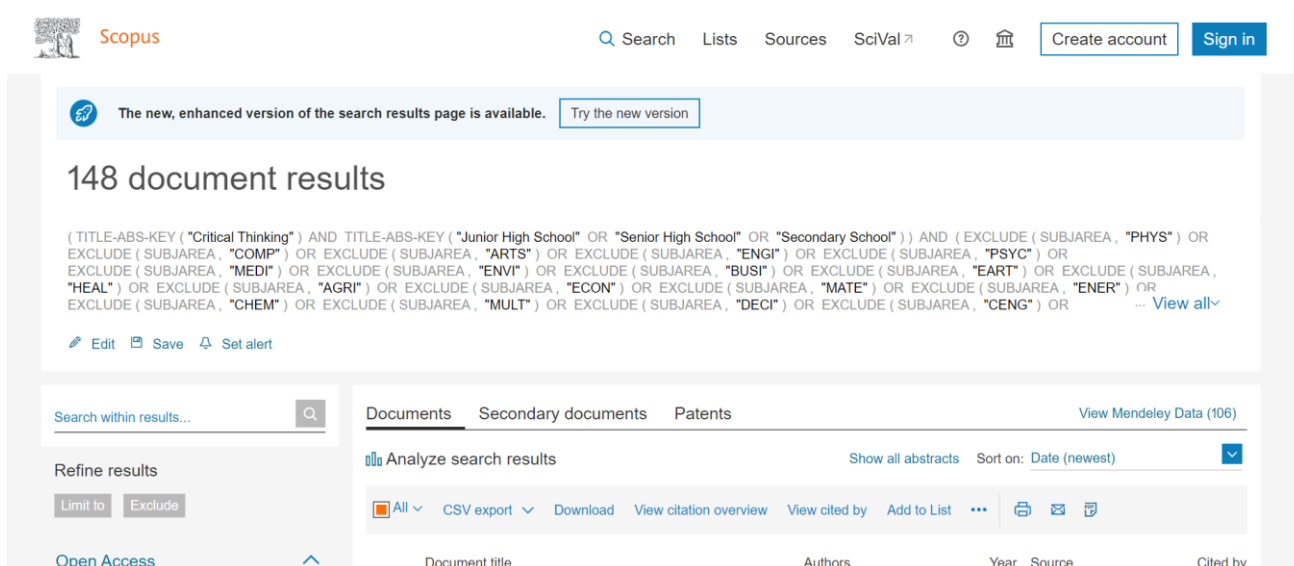


Figure 1. Results of Searches in Scopus

According to **Figure 1**, a total of 148 documents obtained from Scopus between 2019 and 2023 focus on critical thinking. All of these documents-type are articles. All of these articles have been published between 2019 and May 2023. Table 1 below shows the number of articles published between 2019 and May 2023.

Table 1. The Number of Articles

Year	Articles
2019	24
2020	45
2021	31
2022	39
2023	9

According to **Table 1**, the number of articles related to critical thinking has shown an increasing trend over the years. In 2019, there were 24 articles, which rose to 45 articles in 2020. The number slightly decreased to 31 articles in 2021 but rebounded to 39 articles in 2022. As of May 2023, there were only 9 articles related to critical thinking. These trends in the number of articles related to critical thinking offer valuable insights into the research interests within this field.

Table 2. Name of Journal and The Number of Articles

Sources	Number of Articles
International Journal of Instruction	10
Universal Journal of Educational Research	10
Thinking Skills and of Creativity	8
International Journal of Learning, Teaching and Educational Research	7
European Journal of Educational Research	6
International Journal of Evaluation and Research in Education	6
Jurnal Pendidikan IPA Indonesia	5
Journal of Technology and Science Education	4
Kasetsart Journal of Social Sciences	4
Journal for the Education of Gifted Young Scientists	3
Asia Pacific Journal of Education	2
Citizenship Teaching and Learning	2
Curriculum Journal	2
Cypriot Journal of Educational Sciences	2
Educational Sciences: Theory and Practice	2
Eurasia Journal of Mathematics, Science and Technology Education	2
Frontiers in Education	2
International Journal of Interdisciplinary Educational Studies	2
International Journal of Science and Mathematics Education	2
International Journal of Science Education	2
Journal of Baltic Science Education	2
Journal of Educational and Social Research	2
Journal of Social Science Education	2
Review of International Geographical Education Online	2
Scandinavian Journal of Educational Research	2
Science and Education	2
Science Education International	2
Acta Paedagogica Vilnensia	1
Area	1
Asia Pacific Education Review	1
Asian Journal of University Education	1
Canadian Journal of Science, Mathematics and Technology Education	1
Cogent Education	1
Comparative Education	1
Critical Social Policy	1
Cultural Studies of Science Education	1
Curriculum and Teaching	1
Education Research International	1
Educational Studies	1
Educational Technology Research and Development	1
Environmental Education Research	1
Estudios Pedagógicos	1
Eurasian Journal of Educational Research	1
European Journal of Geography	1
Intercultural Education	1
Interdisciplinary Journal of Problem-Based Learning	1
International Journal of Educational Development	1
International Journal of Educational Methodology	1
International Journal of Educational Research	1
International Journal of Learning	1
Internet Journal of Restorative Justice	1
Issues in Educational Research	1
Italian Journal of Sociology of Education	1
Journal for Deradicalization	1
Journal of Content, Community and Communication	1
Journal of Educational Research	1
Journal of Intercultural Communication	1
Journal of Learning for Development	1
Journal of Media Literacy Education	1
Journal of Multilingual and Multicultural Development	1
Malaysian Online Journal of Educational Management	1
Mathematics Teaching-Research Journal	1
Milli Egitim	1
New Educational Review	1
New Zealand Journal of Educational Studies	1
Nordic Studies in Science Education	1
Pedagogika	1
Pegem Egitim Ve Ogretim Dergisi	1
Public Administration and Policy	1
Research in Mathematics Education	1
Research in Post-Compulsory Education	1
Revista de Educación a Distancia	1
Revista Electronica de Investigacion Educativa	1
Statistics Education Research Journal	1
Teaching Education	1
Teflin Journal	1
Theory and Research in Education	1
Turkish Online Journal of Distance Education	1

Table 2 provides information on the number of articles published in various academic journals related to education and critical thinking. The table shows that the International Journal of Instruction and the Universal Journal of Educational Research have the highest number of articles, with 10 articles each, which represents 6.76% of the total 148 articles. This indicates that these journals are highly active in publishing research related to education and critical thinking.

Following closely is the Thinking Skills and Creativity journal with 8 articles, representing 5.41% of the total articles. This journal is known for publishing research on creativity, problem-solving, and critical thinking skills, which are essential in education. The International Journal of Learning, Teaching and Educational Research has 7 articles, representing 4.73% of the total articles. This journal publishes research on various aspects of education, including teaching methods, curriculum development, and educational technology. The European Journal of Educational Research and the International Journal of Evaluation and Research in Education each have 6 articles, representing 4.05% of the total articles. These journals publish research on various topics related to education, including educational policy, assessment, and evaluation. Other journals mentioned in the table include the Jurnal Pendidikan IPA Indonesia with 5 articles, the Journal of Technology and Science Education and the Kasetsart Journal of Social Sciences each with 4 articles, and several others with fewer articles published.

3.2 Documents by country

Applying filters on Scopus, the results are presented in **Table 3**. Indonesia emerges with the highest number of total documents, amounting to 50, followed by Turkey with 8 articles. Malaysia, Netherlands, Hong Kong, and Thailand all have 5 total documents each. Norway and the Philippines have 4 documents each. Ecuador, Germany, Saudi Arabia, South Africa, Sweden, and Tanzania have 3 documents each. The remaining countries have only 1 or 2 total documents each.

Table 3. Total Published documents by County

Country	Total Documents
Indonesia	50
Turkey	8
Malaysia	5
Netherlands	5
Hong Kong	5
Thailand	5
United Kingdom	4
Spain	4
Norway	4
Philippines	4
Australia	3
Ecuador	3
Germany	3
Saudi Arabia	3
South Africa	3
Sweden	3
Tanzania	3
Canada	2
China	2
Finland	2
Greece	2
India	2
Japan	2
New Zealand	2
Taiwan	2
Belgium	1
Brunei Darussalam	1
Croatia	1
Czech Republic	1
Estonia	1
Kenya	1
Malta	1
Nigeria	1
Russian Federation	1
Rwanda	1
Singapore	1
Slovakia	1
South Korea	1
Switzerland	1
United States	1
Venezuela	1
Vietnam	1

According to **Table 3**, it can be seen that Indonesia has the highest number of documents, with 50 documents. This indicates that Indonesia has a significant contribution to research in the field related to the data.

In addition to Indonesia, several other countries also have a significant contribution to research. Turkey has 8 documents, while Malaysia, Netherlands, Hong Kong, and Thailand each have 5 documents. These countries also show a strong interest in conducting research in related fields. On the other hand, there are several countries that have a lower contribution in the number of documents produced. Countries such as Belgium, Brunei Darussalam, Croatia, Czech Republic, Estonia, Kenya, Malta, Nigeria, Russian Federation, Rwanda, Singapore, Slovakia, South Korea, Switzerland, the United States, Venezuela, and Vietnam each have only 1 document.

3.3 Most Relevant Authors

Figure 2 showed that Heru Kuswanto has published the most articles on critical thinking with 4 articles. Hugo Bronkhorst, Martin Geodhart, Dwi Agus Kurniawan, Gerrot Roorda, and Cor Suhre with 3 articles each, and the others only 2 articles.

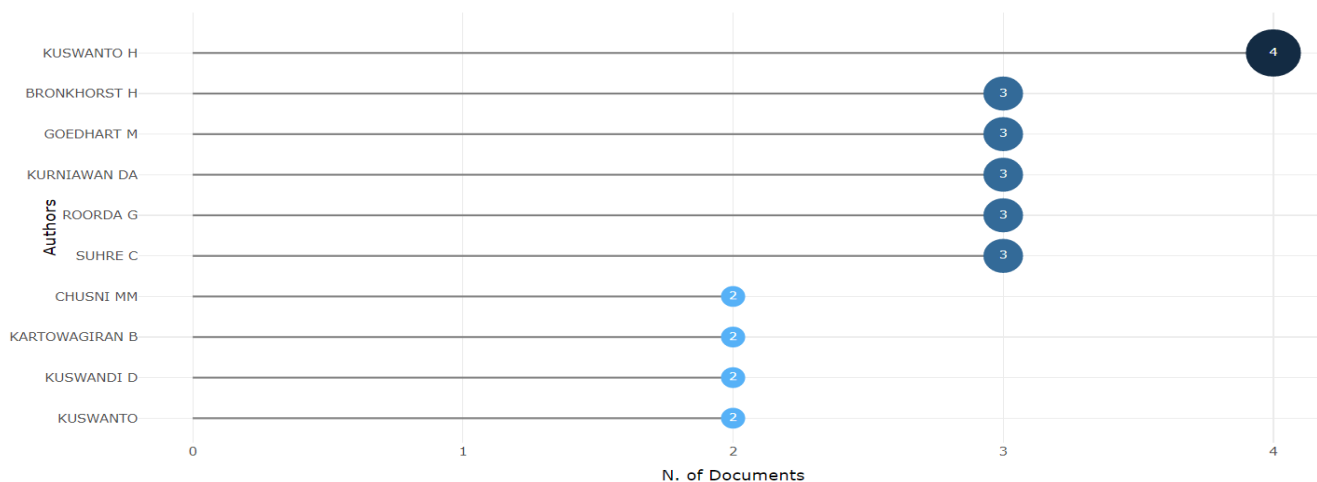


Figure 2. Total Published documents by authors

3.4 Co-occurrence based on authors' keyword

By utilizing the VOSViewer application, the author applied a criterion of a minimum of 2 occurrences among 528 keywords, resulting in 61 keywords meeting the threshold. Figure 4 displays the results of the most frequently used keywords related to critical thinking.

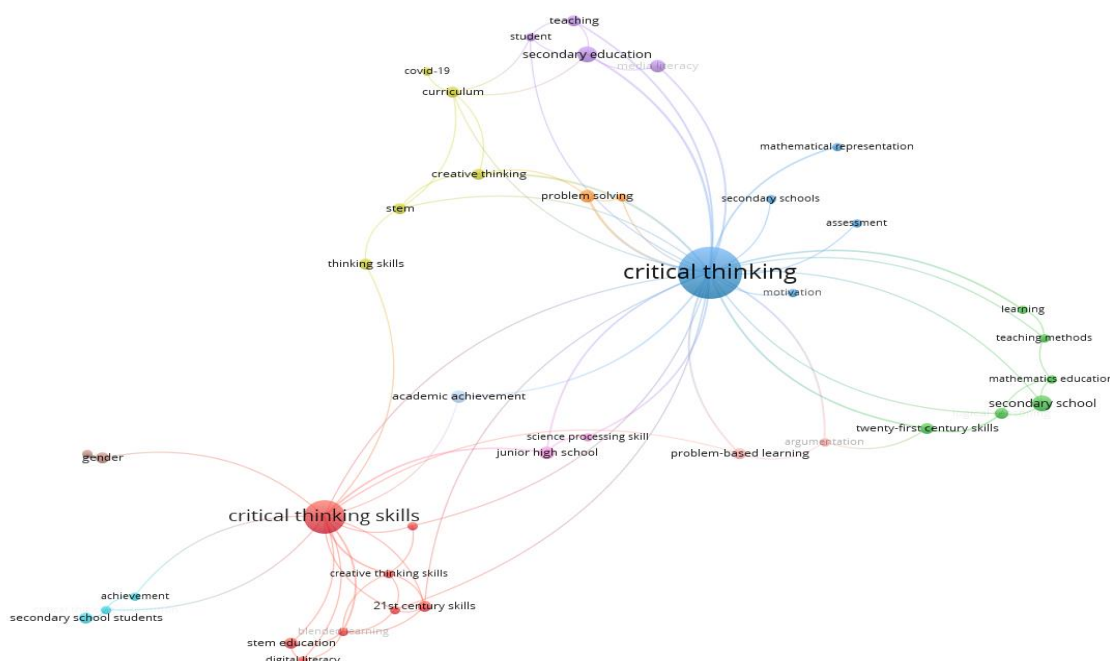


Figure 4. Co-occurrence (network visualization)

According to **Figure 4**, there are 13 clusters. The 'Critical Thinking' cluster (blue-color) appears 51 times with 27 links, while the 'Critical Thinking Skills' cluster (red-color) appears 23 times with 15 links. The 27 links associated with 'Critical Thinking' include teaching, student, secondary education, media literacy, mathematical presentation, secondary schools, assessment, motivations, learning, teaching methods, secondary school, logical reasoning, twenty-first century skills, argumentation, problem-based learning, 21st century skills, metacognitive skills, STEAM, critical thinking skills, STEM, problem solving, creative thinking, and curriculum. Apart from 'Critical Thinking' and 'Critical Thinking Skills', 'Secondary School' and 'Secondary Education' are the most frequently mentioned clusters with 6 occurrences.

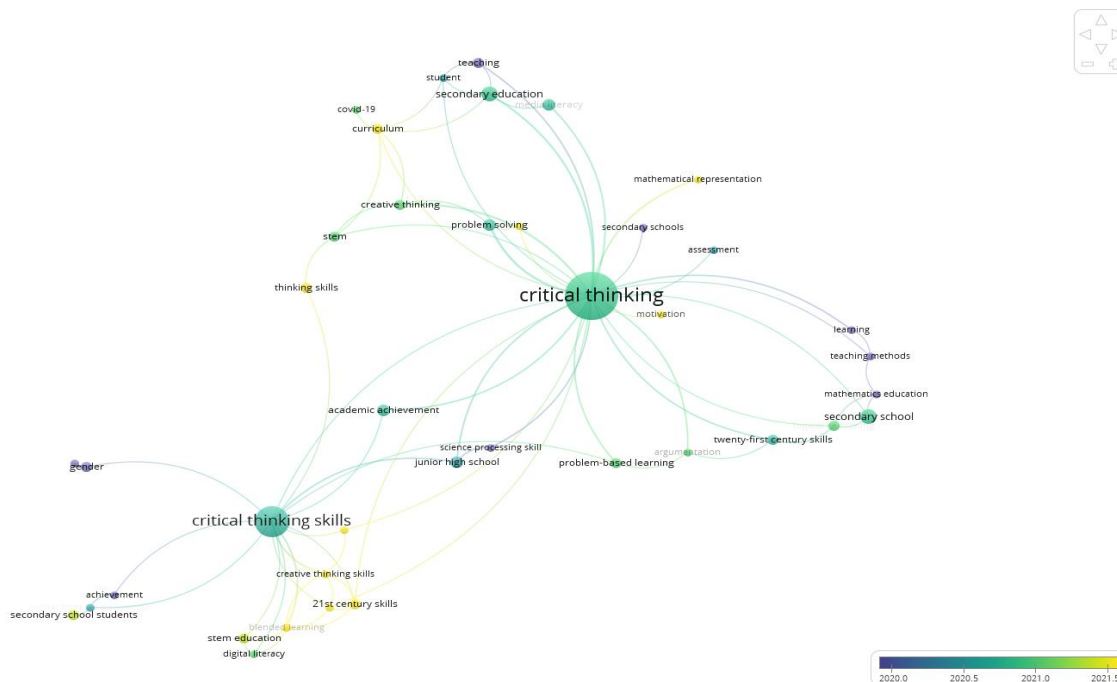


Figure 5. Overlay visualization

Figure 5 depicts the overlay visualization. According to the results, the most recent research on critical thinking in 2021 focuses on secondary school students, STEM education, blended learning, 21st century skills, creative thinking skills, thinking skills, curriculum, creativity, motivation, and mathematical representation.

4. CONCLUSION

Based on bibliometric analysis, data on critical thinking was gathered from Scopus. The search was filtered by subject area, document type, language, and publication year. The results from Scopus revealed a total of 148 documents published between 2019 and May 2023. These 148 documents are articles, distributed across 78 different sources. The International Journal of Instruction and Universal Journal of Educational Research are the primary sources of published documents, with 10 documents each. Among the 148 documents, Indonesia has the highest number of total documents, with 50 articles. In terms of authorship, Heru Kuswanto has published the most articles on critical thinking. The result of co-occurrence analysis based on author keywords indicates that, in addition to 'critical thinking' and 'critical thinking skills', 'secondary school' and 'secondary education' are the most frequently appearing terms, with 6 occurrences each. The most commonly researched topics in documents published in 2021 include secondary school students, STEM education, blended learning, 21st century skills, creative thinking skills, thinking skills, curriculum, creativity, motivation, and mathematical representation.

CONFLICT OF INTEREST

There are no conflicts of interest declared by the authors.

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