

A BIBLIOMETRICS ANALYSIS ON MATHEMATICAL THINKING IN INDONESIA FROM SCOPUS ONLINE DATABASE WITH AFFILIATION FROM INDONESIA

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Abstract:

Developing students' mathematical thinking is one of the most important objectives of mathematics education. Mathematical thinking in Indonesia is the focus of this study, which presents the results of a bibliometric investigation. This study aims to determine the development of mathematical thinking research publications and the distribution of research publications by type of publication, research institutes, and scientific journals in Indonesia on the Scopus online database. This study aims to determine the development of mathematical thinking research publications and the distribution of research publications by type of publication, research institutes, and scientific journals in Indonesia on the Scopus online database. This research is quantitative and descriptive. By collecting data from research on mathematical thinking in Indonesia in scientific journals at Scopus. Bibliometrics R-tool and BiblioShiny were used in this study. According to the findings of this bibliometric study, publication on mathematical thinking attained its pinnacle in 2019, marking the year when it realized its full potential. The publication outcomes are dominated by conference series journals. Authors submit their work to these journals by attending international conferences. Research on mathematical thinking is being conducted at Universitas Pendidikan Indonesia at a higher level than at any other Indonesian university. Furthermore, it is anticipated that future studies will make use of Bradford's theorem in order to present data that is more accurate for the purpose of the development of bibliometric studies.

Keywords: Bibliometric, Mathematical Thinking, R-Studio, Scopus.

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INTRODUCTION

Mathematical thinking is a set of mental operations made easier by the students' prior knowledge of mathematics and their eagerness to solve mathematics problems (Sitorus, 2016). Various heuristic tactics are adapted and their outcomes are monitored and controlled in a meta-cognitive manner, which aids in the problem-solving process (Beng & Yunus, 2015). Mathematics education has a significant role to play in improving students' conceptual understanding, and one of its most important goals is to foster students' mathematical thinking. It is possible for pupils to increase the complexity of their ideas through the use of mathematical thinking (Zeynivandnezhad, Ismail, & Yosuf, 2013).



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When it comes to problem solving, mathematical thinking can be characterized as employing mathematical approaches or concepts (Uyangör, 2019) directly or indirectly. Developing students' mathematical thinking is one of the most important objectives of mathematics education. Mathematical thinking is a way for pupils to expand their understanding of the intricacies of their thoughts (Zeynivandnezhad et al., 2013). It has long been a primary goal of mathematics education to cultivate students' ability to think mathematically (Li, Mok, & Cao, 2019).

The ability of Indonesian students to reason mathematically and solve non-routine problems reveals that students' mathematical thinking skills are not yet up to par (Tanujaya, Mumu, & Margono, 2017). This is evident when students attempt to solve problems that are not routine. The shift in mathematical thought from thinking "inside the box" to thinking "beyond the box" needs to be taught beginning in elementary school (Mahmood, 2015; Muthma'innah, Dahlan, & Suhendra, 2019).

TIMSS 2011 math results showed that Indonesian pupils performed poorly compared to their peers in ASEAN countries. This circumstance raises questions regarding the profile of Indonesian mathematics learning, and it has a connection to the performance on the TIMSS 2011 (Sunawan & Rosjanuardi, 2019; Susongko & Fatkhurrahman, 2017). Another study indicated that, in order to tackle mathematical issues more efficiently, a metacognitive process based on suitable mathematical thinking can be used (Naufal, Atan, Abdullah, & Abu, 2017).

Mathematical thinking has been studied from a variety of perspectives. For example, particular attention has been paid to defining function in relation to the process-object and operational-structural distinctions (Shinno, 2018) There are advantages and disadvantages for each perspective, and a student who is open-minded is able to adapt to a variety of situations. It's more abstract to take the structural (object) approach, which implies that mathematical things are "objects" in the sense that their formal definitions suggest (at the very least symbolically).

Mathematical thinking appears to require a full education, especially for individuals from Indonesia. Because of this, bibliometric analysis was used to track the growth of research on mathematical thinking. The bibliometric method of research has been adopted. In order to better understand how people use published and unpublished sources of information, bibliometrics is the newest method. Analyzing written documents quantitatively is called bibliometric studies (Mishra, Gawde, & Solanki, 2014).

Several previous studies on bibliometric analysis that are relevant to this study are as follows, research from Çoban & Tezci (2022) which reviewed the literature on mathematical thinking from 545 journal articles published until January 2021 was examined using bibliometrics. The Vosviewer software checks the author's most frequently used keywords, bibliographic coupling, and general citations. Meanwhile, Suharso, Setyowati, & Arifah (2021) examines bibliometrics in online scientific publications. Using Vosviewer to develop algorithms and visualization of the Dimension database (Oyewola & Dada, 2022).

This research is focused on bibliometric studies of articles that have been published through Scopus indexed journals on mathematical thinking from 2012-2022. This is different from previous studies that used the Dimension database and

used Vosviewer. This study uses Scopus as a reference database and uses the R package or R programming language to process data from search results about mathematical thinking articles. Mathematical thinking in Indonesia is the focus of this study, which presents the results of a bibliometric investigation. Since the critical evaluation and synthesis of literature is not provided in this article, this article is not a review article. The following are some of the questions the researcher hopes to answer by examining the studies on mathematical thinking.

1. How is the development of research publications on mathematical thinking in Indonesia on the Scopus online database?
2. How is the distribution of research publications on mathematical thinking in Indonesia by type of publication, research institutes and scientific journals?

RESEARCH METHODS

A bibliometric study was carried out with the purpose of analyzing the existing research literature on the subject of mathematical thinking in Indonesia. The first thing that needs to be done in order to finish a bibliometric study is to make a complete list of the publications that could potentially be a part of our sample (Oermann et al., 2008). This is a quantitative descriptive study. Researchers wish to study the evolution of mathematical thinking research outcomes in Indonesia, the distribution pattern of publications based on research affiliations, research topics, and scientific journals in Scopus. Bibliometrix R-tool and BiblioShiny were utilized in this study for the purposes of data analysis, reduction, visualization, and mapping respectively. R-Studio was the version of Bibliometrics that was utilized to do the analysis of the full article mapping (Aria & Cuccurullo, 2017).

Literature search and data collection

The author began their work by conducting a document search within the Scopus database. The search string is made up of a mix of compound keywords and operators that are entered into the search field at the same time. For example, the keyword AFFILCOUNTRY (Indonesia) KEY was used to conduct a search ("mathematical thinking").

Data extraction, loading, and conversion

Following purification by limiting the country to Indonesia exclusively, 88 data were collected in total. The data is then exported for further study from Scopus. In addition, Scopus permits researchers to export data to many file formats, including BibTeX, CSV, Plain Text, and RIS format, among others. In this study, data were exported in CSV format, allowing importation into bibliophily for the bibliometrics application (Aria & Cuccurullo, 2017).

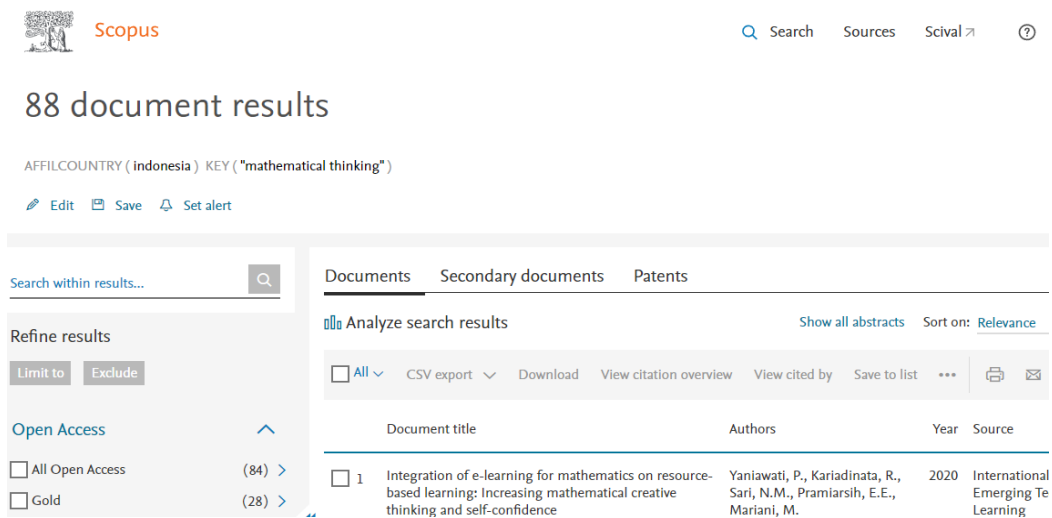
Software and analysis for bibliometrics

This study uses the open-source bibliometric R-package software, which provides bibliometrics capabilities. Aria and Cuccurullo built an R-package in R (Aria & Cuccurullo, 2017). It contains statistical and scientific mapping algorithms. The latest version of the bibliometric R-package (2.0 and later) contains a web

interface application (Biblioshiny) to let non-coders undertake bibliometric analyses. Biblioshiny may import Scopus or Web of Science data in BibTex, CSV, or plain text. Biblioshiny filters data. Our study imports Scopus data using biblioshiny's CSV import.

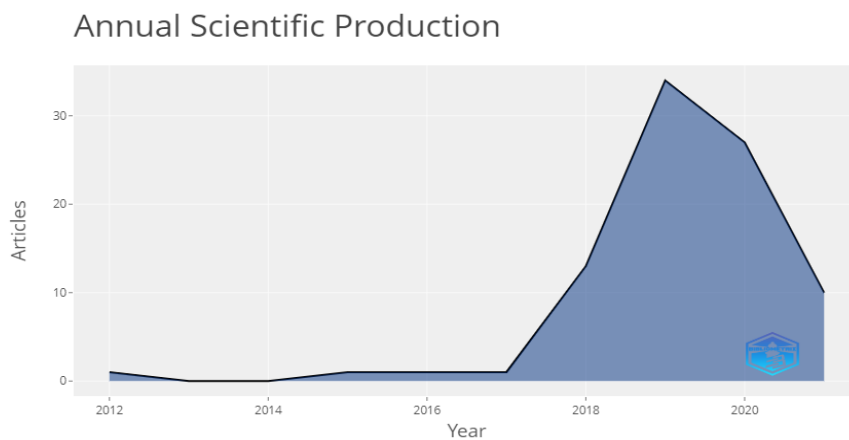
RESULTS AND DISCUSSIONS

According to the data gathered, 88 papers about mathematical thinking in Indonesia have been published in the Scopus online database since 2012. As of June 25, 2022, the investigation had been completed. The keyword AFFILCOUNTRY (indonesia) KEY was used to conduct a search ("mathematical thinking"). Figure 1 shows the results of a search in the Scopus database.



Picture 1. Results of Searches Performed on Scopus Online Database

Using the Scopus online database, you can see the development of Mathematical Thinking research articles in Indonesia between 2012 and 2022:



Picture 2. Annual Scientific Productions

Since 2012-2017, there were just four published papers on the topic of mathematical thinking, but that number jumped to 13 papers in 2018 and 34 papers in 2019. While the number of publications dropped by 27 in 2020, it fell by another 10 in 2021. It's worth noting that from 2012 to 2017, Indonesia has the fewest papers in the subject of mathematical thinking research. With 34 papers, 2019 was Indonesia's busiest year for mathematical thinking research, according to a review. There is a consequent decline in the number of papers published in the Scopus database that deal with mathematical thinking.

It is estimated that between 2012 and 2021, Indonesian researchers published a total of 88 papers linked to mathematical thinking, including 12 journal articles and 76 conference papers. When you consider that the median citations per document are 2.057, the median year-to-year citation rate is 0.5122, and the median number of references is 1876, you arrive at an average. More than 76 publications were identified as Conference papers, as shown in Table 1.

Table 1. Main Information About Data

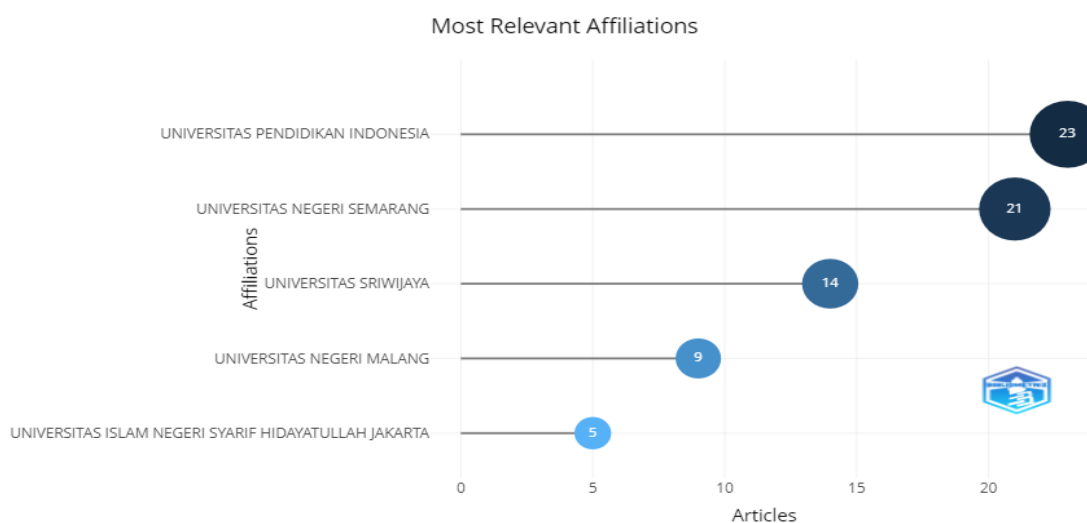
Description	Results
Timespan	2012:2021
Sources (Journals, Books, etc)	13
Documents	88
Average Years from Publication	2.8
Average Citations Per Documents	2.057
Average Citations Per Year Per Doc	0.5127
References	1876
Document Types	
Article	12
Conference Paper	76

Since 2012 to 2021, Indonesian researchers have published a total of 88 publications connected to Mathematical Thinking, including 74 conference papers and the remainder published in academic journals. Journal of Physics: Conference Series has the most Mathematical Thinking research publications in the Scopus online database for 2012-2020, with 74 articles. Considering the large number of conference publications (Table 1 & Table 2) written by Indonesian authors in comparison to the number of non-conference articles. In the future, Indonesian scholars should focus their efforts on this issue in order to increase the number of articles they submit to Scopus-indexed national and international publications.

Table 2. Most Relevant Sources

Sources	Articles
Journal of Physics: Conference Series	74
European Journal of Educational Research	2
Journal on Mathematics Education	2
Acm International Conference Proceeding Series	1
Emerging Science Journal	1
International Education Studies	1
International Journal of Emerging Technologies in Learning	1
International Journal of Instructions	1
International Journal of Learning Teaching and Educational Research	1
International journal of Research in Education and Science	1
Journal of Advanced Research in Dynamical and Control Systems	1
Journal of Engineering Science and Technology	1
Proceedings of The 7th Mathematics Science and Computer Science Education international Seminar Msceis 2019	1

According to a search on the Scopus database, the distribution of affiliations undertaking research on Mathematical Thinking in Indonesia from 2012 to 2021 can be identified by looking at the affiliation ID on the article. With a top 5 position in search results, Universitas Pendidikan Indonesia, with 23 publications, appears to be Indonesia's main implementation institution for Mathematical Thinking research. For positions in ranks 2 to 5 are occupied by Universitas Negeri Semarang (21 publications), Universitas Sriwijaya (14 publications), Universitas Negeri Malang (9 publications), and Universitas Islam Negeri Syarif Hidayatullah Jakarta with 5 publications.



Picture 3. Most Relevant Affiliations

The majority of the local authors cited findings from research on mathematical thinking conducted in Indonesia, and they did so by employing author keywords to acquire data from the top 6 authors who were responsible for producing many papers. Among them, Susanti E has created 9 publications, Hapizah H and Meryansumayeka M have each produced 6, and Dahlan JA, Juandi D, and Prabawanto S have each produced 3 publications. Susanti E has produced 9 publications. The following table provides an overview of the outcomes of the publications produced by the top six authors.

Table 3. Most Local Cited

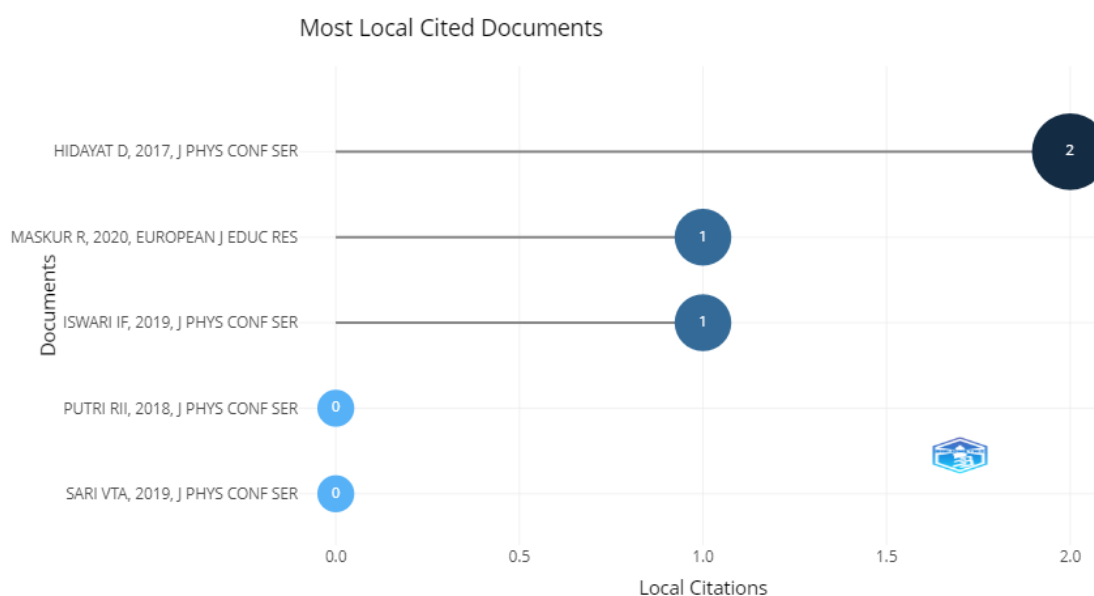
Authors	Articles	Title
Susanti E.	9	(E. Susanti, Hapizah, Meryansumayeka, & Irenika, 2019), (Miswanto, Susanti, Hapizah, Meryansumayeka, & Nurzalena, 2019), (Nurzalena, Susanti, Hapizah, Meryansumayeka, & Miswanto, 2019), (Irenika, Susanti, Hiltrimartin, Hapizah, & Meryansumayeka, 2019), (Nurzalena et al., 2019), (Turidho, Susanti, Hapizah, Meryansumayeka, & Iswari, 2019), (V. D. Susanti, Krisdiana, & Adamura, 2020), (Helviyana, Susanti, Indaryanti, Sari, & Simarmata, 2020), (Alyawati, Susanti, Sari, & Sukmaningthias, 2020), (Khansa, Susanti, Indaryanti, Sari, & Simarmata, 2020)
Hapizah H.	6	(E. Susanti et al., 2019), (Miswanto, et al, 2019), (Irenika et al., 2019), (Nurzalena et al., 2019), (Turidho et al., 2019), (V. D. Susanti et al., 2020)
Meryansumayeka M.	6	(E. Susanti et al., 2019), (Miswanto, et al, 2019), (Nurzalena et al., 2019), (Irenika et al., 2019), (Turidho et al., 2019), (V. D. Susanti et al., 2020)
Dahlan Ja	3	(Hidayat, Nurlaelah, & Dahlan, 2017), (Muthma'Innah, Dahlan, & Suhendra, 2019), (Fisher, Kusumah, & Dahlan, 2020)
Juandi D.	3	(Putra, Suryadi, & Juandi, 2018), (Aristika, Darhim, Juandi, & Kusnandi, 2021), (Juandi & Tamur, 2021)
Prabawanto S.	3	(Ikhwanudin, Wahyudin, & Prabawanto, 2019), (Fakhrunisa & Prabawanto, 2020), (Gaol, Prabawanto, & Usdiyana, 2019)

According to research carried out in Indonesia on the topic of the Most Globally Cited Documents in Mathematical Thinking, the top five most-cited authors are as follows: Putri & Zulkardi (2018), with a total of 26 citations; Maskur et al. (2020), with a total of 22 citations; Sari & Hidayat (2019), with 13, Saragih & Napitupulu (2015), with 13, and (Mudrikah & Hakim, 2016), with 8 citation.

Table 3. Most Global Cited

Paper	Total Citations
Putri RII, 2018, J Phys Conf Ser	26
Maskur R, 2020, European J Educ Res	22
Sari VTA, 2019, J Phys Conf Ser	13
Saragih S, 2015, Intern Educ Stud	13
Mudrikah A, 2016, Int J Res Edu SCI	8

According to the research carried out in Indonesia on the Most Locally Cited Documents in Mathematical Thinking, there are only three influential authors. These authors are as follows: Hidayat D in 2017 in the Journal of Phys Conf Ser with 2; Maskur R in 2020 in European J Educ Res; and Iswari If in 2019 in the Journal of Phys Conf Ser.



Picture 4. Most Local Cited Documents

Table 4. Most Local Cited Documents

Document	Year	Local Citations
Hidayat D, 2017, J Phys Conf Ser (Hidayat et al., 2017)	2017	2
Maskur R, 2020, European J Educ Res (Maskur et al., 2020)	2020	1
Iswari IF, 2019, J Phys Conf Ser (Iswari, Susanti, Hapizah, Meryansumayeka, & Turidho, 2019)	2019	1

To find references from authors or articles on mathematical thinking that are not from Indonesian sources, many authors are cited from several sources such as books, theses or dissertations and articles in reputable journals. The results of the findings obtained are sources that are often cited by affiliated authors in Indonesia apart from articles. One of the most cited is Karadag (2009), who published a

dissertation on mathematical thinking in 2009. PISA (2016) is also used to view the results of measurements of mathematical thinking (Tohir, 2016). For books that are frequently cited by authors, such as books by Stacey (2006).

Table 5. Most Local Cited References

Cited References	Citation s
Karadag, Z., (2009) Analyzing Students' Mathematical Thinking in Technology-Supported Environments (Karadag, 2009)	4
Stacey, K., (2006) What is Mathematical Thinking and Why Is It Important? (Stacey, 2006)	3
Pisa 2015 Results (Volume I): Excellence and Equity in Education, OECD (Pisa, 2016)	2
Argyle, S.F., (2012) Mathematical Thinking: from Cacophony to Consensus (Argyle, 2012)	2
Astuty, E.S., (2019) Unnes Journal of Mathematics Education Research, 8, P. 50 (Astuty, Waluya, & ..., 2019)	2
Butterworth, J., Thwaites, g., (2013) Thinking Skills: Critical Thinking and Problem Solving (Butterworth & Thwaites, 2013)	2
Devlin, K., (2012) Introduction to Mathematical Thinking (Devlin, 2012)	2
Ekawati, E., (2011) Peran, Fungsi, Tujuan, dan Karakteristik Matematika Sekolah, , http://p4tkmatematika.org/2011/10/peran-fungsi-tujuan-dan-karakteristik-matematika-sekolah/ (Ekawati, 2011)	2
Kilpatrick, J., Swafford, J., Findell, B., (2001) Adding IT Up: Helping Children Learn Mathematics, , (Washington DC: National Academy Press) (Kilpatrick, Swafford, & Findell, 2001)	2
Kinard, J.T., Kozulin, A., (2008) Rigorous Mathematical Thinking: Conceptual Formation In The Mathematics Classroom, , (New York: Cambridge University Press) (Kinard & Kozulin, 2008)	2
Lambert, V.A., Lambert, C.E., Qualitative Descriptive Research: An Acceptable Design (2012) Journal of Nursing Research, 16, P. 255 (Lambert & Lambert, 2012)	2
Mason, J., Burton, L., Stacey, K., (2010) Thinking Mathematically (Mason, Burton, & Stacey, 2010)	2
Mason, J., Burton, L., Stacey, K., (2010) Thinking Mathematically Second Edition (Mason et al., 2010)	2
Noyes, A., (2007) (Noyes, 2007)	2
Onal, H., Inan, M., Bozkurt, S., (2017) J. Educ. Train. Stud., 5 (9), P. 133 (Onal, Inan, & Bozkurt, 2017)	2
Posamentir, A.S., Krulik, S., (2008) (Posamentier & Krulik, 2008)	2
Setiawan, W., Sari, V.T.A., The Effectiveness of Cognitive Conflict on The Concept of Differential (2019) J. Phys. Conf. Ser., 1157, PP. 1-6 (Setiawan & Sari, 2019)	2
Van Gog, T, Kester, L, Paas, F, Effects of Worked Examples, Examples, Problems and Examples of Pairs on Novices' Learning (2011) contemp. Educ. Psychol, 36, PP. 212-218 (Gog, Kester, & Paas, 2011)	2

Bibliometric analysis is increasingly being used to review trends and advances in various fields and areas of research. The current data analysis represents the development of mathematical thinking research with limited affiliations from Indonesia. The bibliometric analysis of this study includes the type of publication, author, college affiliation and distribution of citations for each publication that has been indexed by Scopus.

1. How is the development of research publications on mathematical thinking in Indonesia on the Scopus online database?

The development of research publications on mathematical thinking in Indonesia began in 2012 based on the Scopus database which the author found with the article title "Eliciting mathematical thinking of students through realistic mathematics education" by Anwar, Budayasa, Amin, & de Haan (2012). With many researchers studying mathematical thinking, research on this theme has also developed, reaching its peak in 2019 when the whole world was experiencing the Covid-19 pandemic. At that time the articles published in Scopus indexed journals amounted to 34 publications. Therefore, it can be predicted that this research will experience an increasing trend in the next few years even though in 2020 and 2021 it will decrease. This is related to the uncertainty of the situation from the Covid-19 pandemic, so that research on mathematical thinking declined during that year (Tomasik, Helbling, & Moser, 2021).

2. How is the distribution of research publications on mathematical thinking in Indonesia by type of publication, research institutes and scientific journals?

Dissemination of publications from mathematical thinking research in Indonesia Most publications carried out by researchers from Indonesia are dominated by conference articles with 76 article titles. With such a long distance between writing articles on mathematical thinking through proceedings and submitting directly to Scopus indexed journals, this is a problem experienced by writers from Indonesia. Of the 88 documents, only 12 articles were published in Scopus indexed journals by writers from Indonesia.

For campus affiliation, which dominates mathematical thinking research in Indonesia, the writers are from the Universitas Pendidikan Indonesia campus with a total of 23 published articles. The author limits only the big 5 campuses that contribute the most to this mathematical thinking. With a campus that has a mathematics education faculty, it can be assumed that researchers have their own concerns with mathematical thinking. This is evidenced by the names of universities under the Universitas Pendidikan Indonesia in publishing in Scopus indexed journals, such as Universitas Negeri Semarang, Universitas Sriwijaya, Universitas Negeri Malang, and Universitas Islam Negeri Syarif Hidayatullah Jakarta.

Journal Of Physics: Conference Series is a special priority for Indonesian writers in mathematical thinking. From 2012-2022, the European Journal of Educational Research and the Journal on Mathematics Education became Scopus indexed journals that could produce 2 publications each with authors from Indonesia on mathematical thinking. However, the article from Putri & Zulkardi

(2018) with the title "Higher-order thinking skill problem on data representation in primary school: A case study" has been widely quoted globally by other authors.

LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

This investigation is restricted to Scopus-indexed papers and is concentrated exclusively on Indonesia. This research does not provide a synthesis using any of the articles that were acquired because the primary emphasis of this research is placed solely on the bibliometric element. Since our investigation exclusively made use of the Scopus database, the search was conducted in a manner that was completely consistent throughout. In the future, work in this field should verify the most recent findings using data originating only from Indonesia; hence, it will be essential to expand the number of countries that are covered in the study. It's possible that this study will also investigate the development of studies on mathematical thinking in Indonesia.

CONCLUSIONS AND SUGGESTIONS

According to the findings of this bibliometric study, it was found that the quantity of research articles linked to Mathematical Thinking in Indonesia in the online Scopus database changed between the years 2012 and 2021. This publication on mathematical thinking has attained its pinnacle in 2019, marking the year when it realized its full potential. The publication outcomes are dominated by conference series journals. Authors submit their work to these journals by attending international conferences. Research on mathematical thinking is being conducted at Universitas Pendidikan Indonesia at a higher level than at any other Indonesian university. Furthermore, it is anticipated that future study will make use of Bradford's theorem in order to present data that is more accurate for the purpose of the development of bibliometric studies. Because of this, there won't be any questions or misconceptions raised during the discussion.

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