Muntazhimah - Bibliometric Analysis of Mathematics Reflective Thinking based on Scopus Database

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Bibliometric Analysis of Mathematics Reflective Thinking based on Scopus Database

Abstract

Reflective thinking is one of the most critical abilities in learning mathematics. This study aims to reveal bibliometric analysis, including mapping a general overview and exploring research opportunities on 'mathematics reflective thinking.' The articles were derived from Publish or Perish (PoP) software using the Scopus database. A total of 173 articles were found since the beginning of the study on mathematics reflective thinking published until November 2021. After managing the database, this study classified and visualized it using VOSviewer software. Overall, this review provides an appropriate reference for further research on the study of 'mathematics reflective thinking.'

Keywords: bibliometric analysis, mathematics reflective thinking, VOSviewer

1. Introduction

The COVID-19 pandemic has made it inevitable for the education sector to arrive in the era of disruption (Pokhrel & Chhetri, 2021; James et al., 2021). Educational disruption is marked by fundamental changes in learning that takes place rapidly. This condition unavoidably brings various concerns, such as high-level adaptation, inconvenience in online learning, insufficient mastery of the lesson, inadequate infrastructure, gadgets, internet connections, and others. (Muntazhimah et al. al., 2020; Kusumaningrum & Wijayanto, 2020; Basa & Hudaidah, 2021; Mok et al., 2021). Numerous existing problems certainly exacerbate the difficulty of reaching the learning objectives in mathematics. Besides, one of the benchmarks in learning mathematics is thinking ability (Fatmahanik, 2018; Widiyanto et al., 2021).

Thinking ability is divided into two: low-level and higher-order thinking skills. Higher-order thinking skill is needed to solve a math problem (Agustan et al., 2017; Sadijah et al., 2021) and correlates with mathematics competency (Lee et al., 2018; Purwanto et al., 2020). One of the higher-order thinking skills (HOTS) refers to reflective thinking (King et al., 2003; Miri et al., 2007). In mathematics learning particularly, reflective thinking becomes one of the most required abilities (Salido & Dasari, 2019) as it relates to active, dynamic, and careful activities to consider ideas by connecting prior knowledge with a given mathematical problem (Schön, 2010). 1992; Muntazhimah & Wahyuni, 2022). When students are able to think reflectively, they can solve complex problems because their minds are focused, thereby leading them to find appropriate solutions. Reflective thinking also provides opportunities for students to minimize misconceptions by encouraging them to question what they do and why they do it. (Koszalka et al., 2002; Gelter, 2003; Ambrose, 2004).

Several experts have discussed reflective thinking. John Dewey (1993) is the first person who generates scientific treatises on reflective thinking in education. Schön (1992) has also studied how a professional think reflectively in his actions. Moreover, reflective thinking carried out by mathematics teachers has been studied by Aldahmash et al. (2021), while reflective thinking among preservice mathematics teachers has been investigated by Mewborn (1999), Junsay (2016), Agustan et al. (2017), Syamsuddin (2019) and Kholid et al., (2021). Furthermore, mathematical reflective thinking in higher education is reviewed by Funny et al.

(2019). Students' mathematical reflective thinking has also been studied by Muin et al. (2018), Rasyid et al. (2018), Antonio (2020), and Utomo et al. (2021). Nevertheless, a bibliometric analysis of the term 'mathematics reflective thinking' has not been comprehensively scrutinized yet.

Articles published and indexed by Scopus were analyzed. This analysis can identify what subjects are being the concern of some additional publications and the subsequent 'mathematics reflective thinking' topics that offer any possibilities for further research. The methodology implemented to conduct the analysis is bibliometric analysis, including the stages of the approach related to implementing Scopus records, primarily based on Publish or Perish (PoP). Then, the consequences of using VOSviewer, followed by the explanation from the literature observed using bibliometric analysis, are presented in the discussion and the conclusion parts. Bibliometrics effectively provides a dataset that may be used for coverage makers, researchers, and stakeholders to enhance the quality of the research (Nandiyanto et al., 2020).

2. Method

This research method adapts the stages of bibliometric research previously conducted by Aribowo (2019), Hamidah et al. (2020), and Shukla et al. (2020). The entire articles used to explore studies on mathematical reflective thinking skills utilized the database of articles that have been published on Scopus. Scopus was chosen because it has strict publication standards and is one of the most comprehensive peer-reviewed databases that made it possible to obtain comprehensive scientific data (Ahmar et al., 2018; (Kapla & Slaby, 2018). Metadata articles recorded in the Scopus database were downloaded in *.ris format, which was processed using Publish or Perish (PoP) software. There were 173 articles published since the onset of the research on mathematical reflective thinking until the present (November 27, 2021). Then, VOSviewer software was used for bibliographic analysis. VOSviewer can visualize the relationship between subjects and citations, group the articles, create publication maps, and describe trends in the existing articles (Leung, 2019; Pratama et al., 2020; Hudha et al., 2020; Xie et al., 2020).

3. Results and Discussion

A total of 173 articles were derived from the Scopus database using PoP software. The output of metric data is presented in Table 1. The year of publication is not changed (0 – 0), which means that the data for the articles were gathered from the beginning or since mathematical reflective thinking research was published until this study was conducted. Bibliometric analysis was then conducted for all articles employing VOSviewer. Vosviewer will determine the keywords that frequently appear and the number of keywords tailored to the data analysis needs. VOSviewer also creates a bibliometric visualization map of the research data. The bibliometric map was then divided into three different visualizations, including network, overlay, and density visualizations.

Table 1. The output of Citation Metrics

Metric Data	Result
Source	Scopus
Publication Year	1916-2021
Papers	173
Citation	1253
Cites/Year	11.93
Cites/paper	7.24
Authors/paper	0.97
h_index	18
g_index	31
hl_norm	18
hl_annual	0.17

Out of 173 articles, we present those with the most relevant contribution to this study, ten articles with the highest citations, as demonstrated in Table 2.

Table 2. Articles with the higher citations

No	Cites	Authors	Year	Publisher
1	126	N. Kersting	2008	SAGE Publications Inc.
2	95	D. Maor	2003	Routledge
3	83	K. Weber	2008	National Council of Teachers of Mathematics
4	71	S.L. Stockero	2008	Springer Netherlands
5	68	H. Phan	2008	Wiley-Blackwell
6	54	D. Mewborn	1999	National Council of Teachers of Mathematics
7	46	H.P. Phan	2006	Universidad de Almeria
8	37	L. Pareto	2014	Springer US
9	27	A. Gagatsis	1990	Springer Netherlands
10	26	D. Pritchard	2010	Taylor and Francis Ltd.

Based on Table 2, Nicole Kersting's (2008) article has the highest citation rate indexed by Scopus with 126 citations. This article examines a new approach to measure teachers' knowledge of teaching mathematics. The ability to think reflectively is linked to the learning analysis process that reflects their teaching knowledge (Kersting, 2008). Meanwhile, the publisher with the highest citation is Sage Publishing.

Earlier published articles associated with mathematics reflective thinking are presented in Table 3.

Table 3. Earlier published articles

No	Authors	Title	Year	Journal
1	W. Gore	Memory, concept, judgment, logic (theory)	1916	Psychological Bulletin
2	R. Tissot	Symptom choice in neuroses	1980	Annales Medico-Psychologiques
3	E. Wittmann	The complementary roles of intuitive and reflective thinking in mathematics teaching	1981	Educational Studies in Mathematics
4	M. Jurdak	The facilitating effect of structured games in mathematics	1982	International Journal of Mathematical Education in Science and Technology
5	G. Blein	Some aspects of the schizophrene's cognitive activities, IV, imbalance between assertions and negations	1990	Annales Medico-Psychologiques

The result was extracted from the title; the minimum variety of occurrences was set to three. Approximately 31 phrases were determined, and 504 terms met the threshold. Common phrases were excluded in this term; it thus turned 29 out of 31 terms. Every term representing the keyword was added by employing the scale of the node. In other words, the node scale suggests the prevalence frequency of the phrase. Five clusters were diagnosed in this case. The key phrases that appear in every cluster portray the stream of research on mathematics reflective thinking, as illustrated in Table 4. Items that emerge in the same cluster indicate a strong relationship. *Mathematics, mathematics education, teacher, teaching,* and *reflection* are interrelated in several studies that have been conducted (cluster 1). Similarly, *critical thinking* and *students' understanding* are closely linked to *reflective thinking skills* (cluster 2), and so on.

Table 4. The Cluster and Items

Cluster	Items
Cluster 1 (red)	Mathematics, mathematics education, reflection, study, teacher, teaching, transition
Cluster 2 (green)	Critical thinking, effect, project, reflective thinking skills, student, understanding
Cluster 3 (blue)	Change, development, mathematics teacher, practice, prospective mathematics teacher, reflective thinking
Cluster 4 (yellow)	Analysis, impact, problem, reflective thinking ability, stem education,
Cluster 5 (purple)	Case study, cognitive style, mathematical problem, process, prospective teacher

The output of network visualization with the keyword *mathematics reflective thinking* derived from the Scopus database is depicted in Figure 1, overlay visualization in Figure 2, and density visualization in Figure 3. These visualizations can be used to gain a targeted description of the structure of bibliometrics (Waltman et al., 2010).

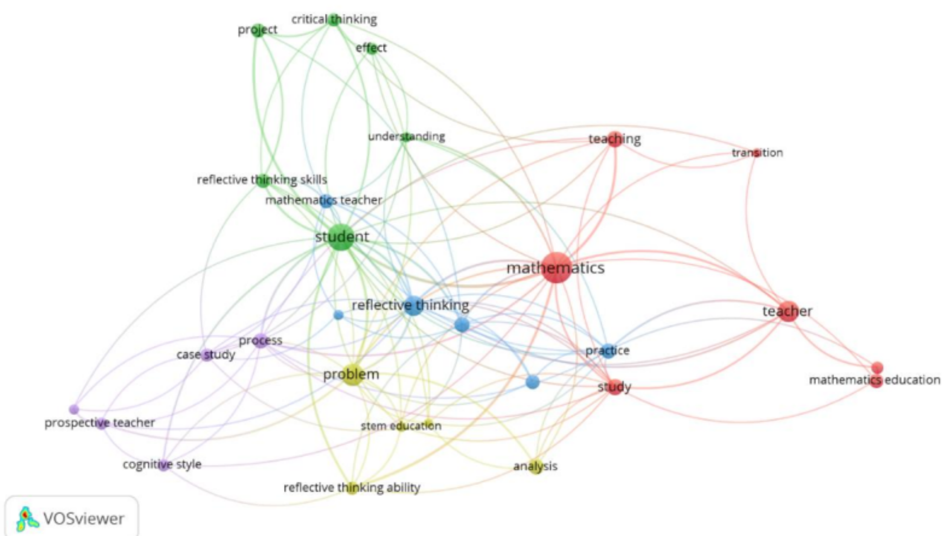

Figure 1. Network visualization

Insight on the grouping of each bibliometric keyword has been attained from clusters in Table 4. A detailed description of the bibliometric structure is demonstrated in the network visualization (see Figure 1); as such, clustering and visualization complement each other. Figure 1 consists of nodes and edges. The node represents the keyphrase that frequently appears; on the other hand, the scale of the node indicates the number of articles relevant to the keyphrase. The edge describes the relationship between two nodes, in which the distance between the nodes denotes the link strength. The closer the distance between the nodes, the stronger the relationship between the two terms in a study. To illustrate, in the purple node, *prospective teacher* has a stronger relationship with *cognitive style* than with *the case study*.

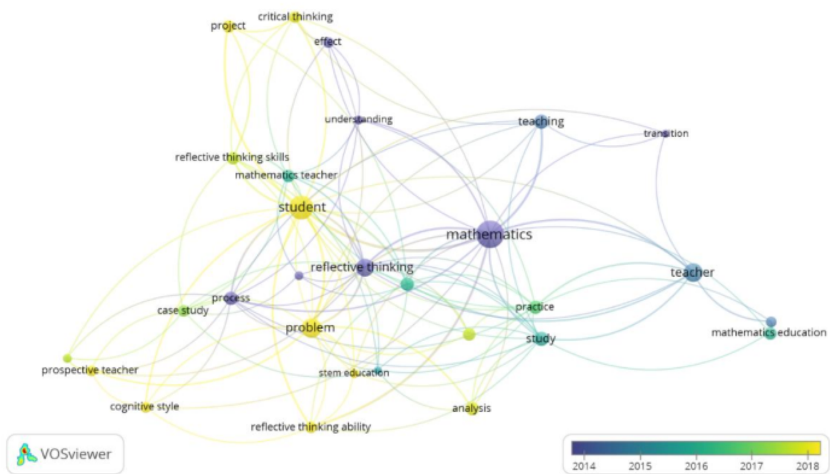

Figure 2. Overlay visualization

After network and cluster analysis for mathematics-reflective-thinking research, we mapped research trends based on the article's publication year. This information is obtained through the output of the overlay visualization in Figure 3. State-of-the-art research that has been conducted is detectable and identifiable through this step. In this visualization, the color of a node represents the year when the article containing the keyphrase was published. The darker the color, the earlier the term was discussed in the research. The visualization in Figure 2 illustrates that topics related to mathematics reflective thinking, either in teachers or teaching, were discussed prior to and until the year 2016. Meanwhile, the current trends include topics concerning mathematics reflective thinking for prospective mathematics teachers, students, analysis, critical thinking, and cognitive style.

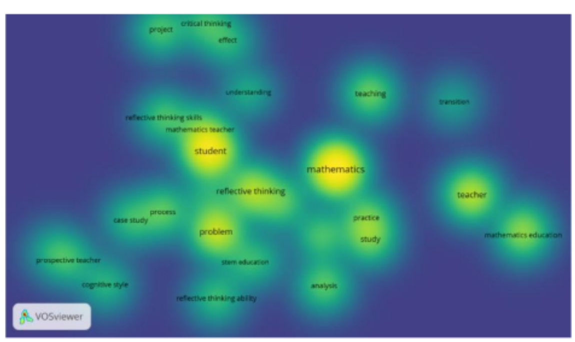

Figure 3. Density visualization

Density visualization in Figure 3 depicts research topic saturation. The dense area is described by the number of adjacent nodes and colors, indicating the saturation level. For instance, the yellow color surrounds the terms *mathematics, teacher, student, problem, mathematics education,* and *study*. It indicates that these topics have been widely studied. In contrast, the topics in green, such as *critical thinking, understanding, prospective teacher, cognitive style, reflective thinking skills, reflective thinking ability, analysis,* and *stem education*, are remarked as rarely studied topics.

These findings reveal existing research gaps and huge opportunities to conduct mathematics reflective thinking research on relevant topics. Aligned with Liu et al. (2015), overlay visualization and density visualization analysis are used to identify key themes in each study. Therefore, the data can be employed as a starting point for future studies.

2. CONCLUSION

The present study has elaborated the mapping and clustering of research themes on mathematics reflective thinking, derived from the metadata of 173 articles in the Scopus database from the earliest year to November 2021. The dominant research topics comprise *reflective thinking in teachers, teaching, students, mathematics*, and others. Along with its development, new topics have emerged, such as *prospective teachers* and their relation to other thinking skills, *cognitive style*, *analysis*, etc.

However, this study is still limited to (meta)data derived from the Scopus database and used Publish or Perish (PoP) and VOSviewer to map visualizations and cluster the research topics. Therefore, it is necessary for future bibliometric studies to use a more extensive database or utilize other databases, such as Web of Science® or Crossref®, with more diverse sources. Other free software is also recommended, such as Pajek, Gephi, and CiteNetExplorer, as alternative software for processing metadata.

Finally, this study is part of a literature review from a dissertation on mathematics reflective thinking processes under the supervision of Turmudi and Sufyani Prabawanto at the doctoral program of mathematics education at Universitas Pendidikan Indonesia. However, the limitations of this article entirely become the author's responsibility without doubting the professionalism of the two promoters.

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