BIBLIOMETRIC ANALYSIS OF MATHEMATICAL COMMUNICATION SKILLS USING SCOPUS DATABASE

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Abstract

The purpose of this study is to analyze how the development of research publication trends in mathematical communication skills in mathematics learning for the 2016-2021 period published in Scopus indexed scientific journals, review citation analysis, and examine trend analysis of terms or keywords by authors in journals and journals. The sample uses 142 article titles. Bibliometric analysis methods through quantitative studies are used to collect, process, and analyze data related to mathematical communication skills in mathematics learning. Data retrieval using PoP (Publish or Perish) software. Data analysis is descriptive quantitative. The results showed that the trend of scientific publications regarding the trend of mathematical communication skills increased from 2016-2021. It can be seen from the data that the number of articles published during 2019-2020 was the most researched on mathematical communication skills. The most cited articles related to mathematical communication skills occurred in 2019 with 97 citations. The Pisa question, communication technology, prospective mathematics teacher and self-efficacy are variables that are still rarely studied.

Keywords: *Mathematical Communication Skills, Bibliometrics, Scopus, VosViewer.*

INTRODUCTION

Mathematics a very important science in the advancement of science and technology (IPTEK). In accordance with Kadarisma (2016), which states that mathematics is a useful science for many people. Therefore, students are required to master mathematics so that students can really understand mathematics and feel its usefulness. One of them is by communicating well. Communication itself is an important part of student learning. Good communication skills will be very beneficial for them in the future. Communication is not only important for math classes, but in all subjects. All educators know how important it is to be able to communicate with students, let

students communicate with each other, and let students understand what they are communicating (Wichelt & Kearney, 2009). According to The National Council of Teachers of Mathematics (2000), teachers should help students clarify their statements, pay close attention to problem conditions and mathematical explanations and refine their ideas. Good communication skills start from the teacher. We know teaching maths teachers shouldn't just write on the blackboard they should explain algorithms when solving problems and expect students to follow them (Harbaugh et al., 2008). One of the most important skills is the ability to communicate mathematically to solve a problem, especially in mathematics.

Mathematical communication ability is a very important ability that must be possessed by students. Mathematical communication skills can be explained as the ability of students to go through dialogue events or reciprocal relationships that occur in the classroom, where the transmission of information occurs (Nofrianto et al., 2017). According to Ahmad & Nasution (2018) mathematical communication skills, namely the process of delivering information from someone directly (verbally) or indirectly (through the media) to other people. Mathematical communication ability itself can provide reasonable reasons for solving problems, can change the form of description in mathematical models, and can explain mathematical ideas or thoughts in the form of related descriptions (Hendriana & Kadarisma, 2019). From the opinions of several experts above, it can be concluded that mathematical communication is one of the abilities

that must be possessed by every student.

By learning mathematics, students are expected to be able to communicate mathematically in solving problems. For this reason, in learning mathematics, students are expected to have mathematical communication skills in order to get satisfactory results. Next Ansari in (Ahmad & Nasution, 2018) states that the indicators of students' mathematical communication skills in learning mathematics are (1) expressing mathematical thoughts through oral, written, presentation, and describing mathematical thoughts in visual form, (2) understanding, explaining, and evaluating mathematical thinking, (3) using language, symbols, and mathematical structures to express ideas, draw relationships, and build models.

Given the importance of mathematical ability in learning mathematics, further research is needed on mathematical communication skills. Therefore we need a way to process the data so that it can be used for various purposes, such as identifying further research that is still rarely done. Entering the early 21st century, the use of citations is still the only recognized method of evaluating quantitative (bibliometric) publications. This method is used to evaluate journals making citation of all journal publications the only recognized standard (Guz & Rushchitsky, 2009). Bibliometrics and scientrometrics were introduced in 1969 by Pritchard and Nalimov and Mulchencko. Pritchard said that bibliometrics is a method of applying mathematics and statistics to books and other communication media. Nalimov

and Mulchencko define scientrometrics as a qualitative method, scientific analysis as information processing (Eck & Waltman, 2014). According to Mubarrok & Rahmawati (2020), bibliometric analysis is a bibliographic analysis of scientific activities, and the assumption is that the researcher must relate the research he is studying with other research. The purpose of the bibliometric analysis is to explain the process of written communication, descriptive calculations and analysis of the nature and direction of development of various aspects of communication (Novia, 2020). Research publications published in scientific journals are the main research objects in bibliometrics (Agustina et al., 2021).

In bibliometric analysis, the researcher will reveal the development of the literature, such as the number of publications, the subject of the article, and the research method. The three components of bibliometrics are: (a) bibliometrics for bibliometricians is the main field of bibliometric research that is traditionally used as a research method; (b) bibliometrics for scientific disciplines (scientific information), considering the extent to which researchers are science-oriented, they have a very strong interest in the field of specialization, and they allow common frontiers with quantitative research in the realm of information retrieval; (c) bibliometrics for science policy and management (science policy), namely various topics in the field of research evaluation (Glenisson et al., 2005). The most common indicators observed using bibliometric analysis include publication classification, citation, author,

publication impact, and country (Ahmi & Mohamad, 2019). The data sources (databases) used in the bibliometric analysis are Google Scholar, Scopus, and Web of Science (WoS).

Web of Science (WoS) and Scopus are still the main sources of data citations. In addition, the interdisciplinary scope of the database is one of the strengths for study and comparison in various fields of science (Archambault et al., 2013). Scopus is a library database containing abstracts and academic journal articles. Scopus contains about 22,000 publications from 5,000 publishers, of which 20,000 are journals in the fields of science, engineering, medicine, and social sciences (including arts and humanities). This database (database) is owned by Elsevier and can be subscribed online. The Scopus search also includes a patent database search (Effendy et al., 2021). The unified method of mapping and clustering bibliometric networks shows that both the VosViewer mapping technique and the weighted and parameterized variants of modularity-based clustering can both be derived from the same basic principle (Waltman et al., 2010). VosViewer is a free computer program that can be used to visualize and explore bibliometric knowledge graphs (Hamad et al., 2019). Vos stands for VosViewer, namely Visualization of Similarities. The algorithm used in this program is almost the same as Multi Dimensional Scaling (MDS). VosViewer database files support four types of bibliographic database files: Web of Science files, Scopus files, Dimensions files and PubMed (Wong & Romano, 2018). Interactive options and program functions make it easy to access and explore a network of

bibliometric data, such as number of citations or co-occurrence relationships between key terms and concepts (Zahedi & Eck, 2014).

Based on previous research conducted by Julius et al. (2021) over the last few years, there has been an important growth in publications in the various sub-fields of mathematics education. The themes of the study of mathematical knowledge for teachers, active learning, inquiry-based learning, geogebra, and statistical education research are some of the most well known. We can conclude that there needs to be further research on mathematical communication skills to find out the trend of research on this topic.

Therefore, the purpose of this study is to analyze how the development of research publication trends in mathematical communication skills in mathematics learning between 2016-2021 which are published in Scopus indexed scientific journals, examine citation analysis, and examine trend analysis of terms or keywords by the author.

METHODS

This research uses international publications on mathematical communication in mathematics learning using the Scopus database (www.scopus.com) as many as 142 articles from 2016 to 2021 contain studies of mathematical communication skills, mathematics, author's name, year of publication. The method of bibliometric analysis through quantitative studies is used to collect, process, and analyze data related to mathematical communication skills in mathematics learning. Publish or Perish (PoP) is

used to collect data and use VosViewer for data visualization.

This research method adopts a five-stage method (Hudha et al., 2020) shown in Figure 1. These five steps include defining search keywords, initial search results, narrowing search results, preparing initial data statistics and data analysis.

Figure 2. shows the first step of collecting *database* by searching using keywords related to mathematical communication skills in Scopus. The data used is already available in the Scopus database, this is secondary data.

The way to get the data is: first, visit www.scopus.com, second, limiting the search on the search menu by entering the keyword "mathematical communication skills", and selecting "data range" article publication by writing the numbers "2016" to "2021", third, selecting or specifying the type of document by clicking "journal", the fourth is to click "search" to get data from the Scopus database, Fifth, save the search result data in RIS format, the goal is that the data can be processed using Microsoft excel and VosViewer tools, that will be explained in Figure 1 and 2.

Furthermore, the results of data collection are stored in RIS format. In this study, the data that was processed in the form of scientific journals about mathematical communication skills in mathematics learning was analyzed by year, author, title, and subject using Microsoft excel 2019. VosViewer software was used to analyze and visualize the bibliometric network of maps of the development of scientific publications of mathematical communication skills in mathematics learning. The display of data

processing using Microsoft excel is in the form of graphs, and the output of VosViewer is a network map based on

keywords and by author. The next step is to log in to VosViewer to visualize the analysis results.
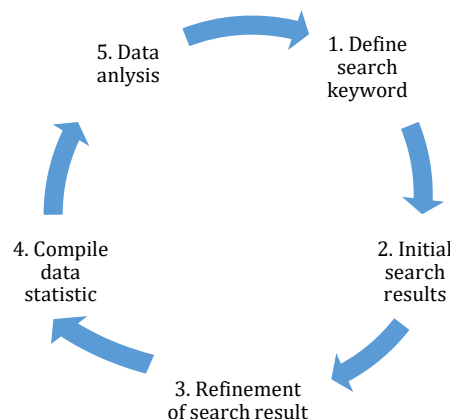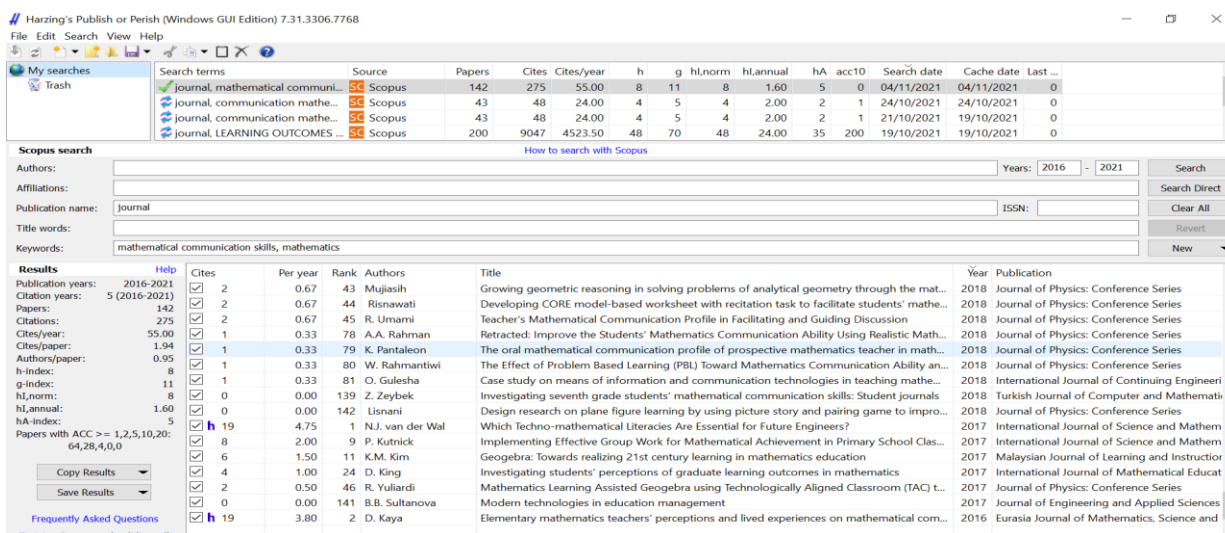

Figure 1. Bibliometric analysis steps

Figure 2. Scopus database search

RESULTS AND DISCUSSION

The results of data collection and analysis related to mathematical communication skills in mathematics learning can be seen in Table 1. From Table 1 we can get information that the highest number of published articles on mathematical communication skills in mathematics learning is in 2020 (38.1%). Research articles on mathematical communication skills published in Scopus indexed journals

generally show positive growth. Table 1 shows that research has increased from year to year, which means that researchers' interest in mathematical communication skills research in mathematics learning has increased from year to year. These results show that writing productivity related to mathematical communication in a certain amount of time is very effective (Ellegaard & Wallin, 2015).

The results of searching the Scopus database, it was reported that the first publication of research on mathematical communication skills, namely the article entitled "Elementary mathematics teachers' perceptions and lived experience on mathematical communication" was written by D. Kaya. in the Eurasia Journal of Mathematics, Science, and Technology Education in 2016.

Table 1. Development of mathematical communication skills articles

Publication Year	Total	Percentage
2016	1	0,7
2017	6	4,2
2018	16	0,11
2019	36	25,4
2020	54	38,1
2021	29	20,4

Based on these data, it is known that with the development of time and technology, researchers are interested in publishing research articles related to mathematical communication skills in mathematics learning at school and university levels.

For the purposes of citation analysis, the frequency with which a work is discussed or discussed by scientists can be seen from the frequency with which a work is cited (Hung, 2012). One way to check the quality of published scientific works is to count how many times the work has been cited by other researchers, and a work called citation means that it has a useful meaning in the scientific field, of course in the academic field of a scientific nature. The results of the citation analysis from this study show that the number of citations per year from 2016 to 2021 is 275 times. Quote mode shows different modes. From 2016 to 2021, the citation appeared the most in 2017, with 19. Related articles in 2017-2021 there are several articles that are not or have not been quoted, meaning 0 citations. There are 4 most cited articles from 2016 to 2021. The details are in table 2:

Table 2. Article with the highest number of citations

No	Writer's Name	Article Title	Publication Year	Journal Name	Number Of Quotes
1	NJ Van Der Wal	Which Techno-mathematical Literacies Are Essential for Future Engineers?	2017	International Journal of Science and Mathematics Education	19
2	D. Rich	Elementary mathematics teachers' perceptions and lived experience on	2016	Eurasia Journal of Mathematics, Science, and	19

No	Writer's Name	Article Title	Publication Year	Journal Name	Number Of Quotes
		mathematical communication		Technology Education	
3	M. Dockendorff	ICT integration in mathematics initial teacher training and its impact on visualization: the case of GeoGebra	2018	International Journal of Mathematical Education in Science and Technology	15
4	S. Hartinah	Probing-prompting based on ethnomathematics learning model: the effect on mathematical communication skills	2019	Journal for the Education of Gifted Young Scientist	15

According to the data in Table 2, the research article entitled "Which Techno-mathematical Literacies Are Essential for Future Engineers?" is the most cited article. The article was written by NJ Van Der Wal and published in 2017 in the International Journal of Science and Mathematics Education which has a lot of good influence on relevant knowledge related to mathematical communication skills in learning mathematics. This can be used as a basis for further research.

Analysis for keyword trends by the author aims to measure the strength of words (terms) and count the number of keywords that appear in research articles, this is an analysis that aims to analyze patterns, content, and trends (tendencies) of a collection of documents (López-Robles et al., 2019). To analyze patterns, content, and trends from a document set. According to the analysis of the VosViewer software, data was obtained for 397 words, using the number of occurrences of the minimum value (least) or the number of occurrences of words that were repeated as much as 2 words. Then choose the most relevant words to be processed as many as 59 words. The results of the visualization are obtained as follows in word repetition.

Based on the data in figure 3 results of the analysis of terms or keywords in the article mathematical communication skills in mathematics learning, the most related are "mathematics communication skills", "analysis", and "student mathematical communication skills, realistic mathematics education". The purpose of this mapping is to find out what knowledge researchers have done the most in the last 5 years. The details of the 8 cluster terms or keywords from the results of the analysis using VosViewer:

1. The first cluster (red color) consists of 11 terms or keywords, namely digital technology, elementary school student, mathematical communication, mathematical communication profile,

mathematical literacy, problem, prospective math teacher, prospective mathematics teacher, role, self efficacy, teacher.

2. The second cluster (green) consists of 10 terms or keywords, namely analysis, design, development, effectiveness, mathematics problems, middle school students, realistic mathematics education, technology, vocational high school students, worksheets.

3. The third cluster (dark blue) consists of 8 terms or keywords, namely contextual teaching, geogebra, geometry, impact, mathematical communication problems, student mathematical communication abilities, tools, visualization.

4. The fourth cluster (yellow color) consists of 7 terms or keywords, namely case study, grade, investigation, mathematical problem, mathematics education, pisa type, student.

5. The fifth cluster (purple) consists of 7 terms or keywords, namely gender, junior high school, junior high school student, mathematical communication skills, mathematics communication ability, pjbl (project base learning), student mathematical communication skills.

6. The sixth cluster (blue color) consists of 7 terms or keywords, namely ability, algebra, communication skills, student grade, model, student mathematical communication, trigonometry.

7. The seventh cluster (orange color) consists of 5 terms or keywords, namely effect, learning, mathematical communication, outcome, strategy.

8. The eighth cluster (brown color) consists of 4 terms or keywords, namely communication technology, education, number, relationship.

Of the 8 clusters, it can be concluded that the first cluster with the most frequently used keywords is mathematical
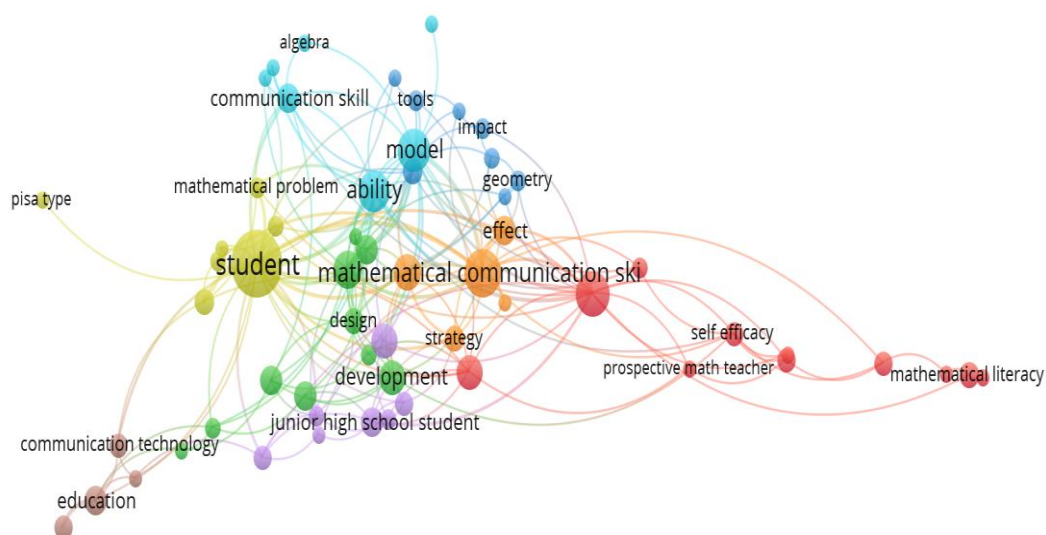

Figure 3. Results of network visualization of keyword author articles mathematical communication skills in mathematics learning
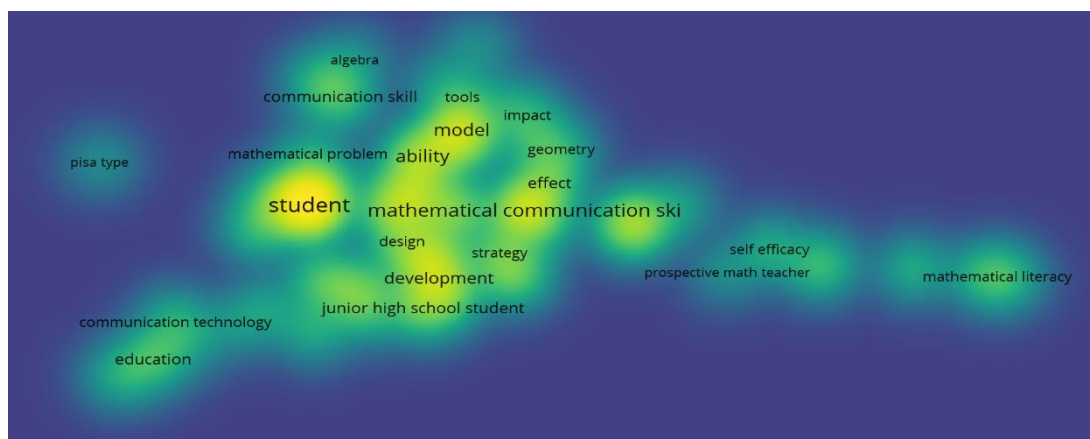
Figure 4. The results of the analysis are seen from the density visualization based on the terms or keywords that often appear along with their level of relevance

Based on the data in Figure 4. we can conclude that the terms or keywords that are rarely used related to mathematical communication skills in mathematics learning are self-efficacy, relationship, outcome, contextual teaching, realistic mathematics education. Furthermore, these terms or keywords can be used as a reference for further research in the future. This shows that the research opportunities on this matter are still very wide, in line with research conducted by Syamsiah et al. (2022) showing that there are still many opportunities for this research, many topics.

The topics discussed were mathematics and problems, the topics that were slightly discussed were mathematics education, the topics that were less discussed were reasoning, mathematical problems, teaching, science, and the topics that were least discussed were mathematics teaching, math, technology.

CONCLUSION

Research articles on mathematical communication skills in mathematics learning published in Scopus indexed journals generally show positive growth from year to year. This shows that article writers from various countries have a higher research interest in mathematical communication skills. It can be seen from the data that the number of articles published during 2019-2020 was the most researched on mathematical communication skills. The most cited articles related to mathematical communication skills occurred in 2019 with 97 citations.

Based on the research that has been done, the authors recommend further research to use different methods and databases, such as using Google Scholar or it could be direct research involving other people so that a more comprehensive knowledge map is obtained. Variables that are still rarely studied related to mathematical communication skills are Pisa questions, communication technology, prospective mathematics teachers and self-efficacy.

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