Mapping Research Developments on Mathematics Communication: Bibliometric Study by VosViewer

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ABSTRACT

This research aims to determine the map of the development of research on Mathematics Communication, namely a study of bibliometrics by VosViewer. The study was conducted starting in January 2021 by searching the keyword “Mathematics Communication” in the Science Direct database and choosing the open access system. The search result data is then stored in the form of a Research Information System (RIS) and analyzed descriptively using VosViewer to see developments on the topic from year to year, the types of documents that are widely published, the name of the author who has discussed the most about the case, the name of the publishing institution and the topics that appear most frequently from thousands of journals that have been processed using VosViewer. The results showed that the map of the development of research on Mathematics Communication has existed since 1997 and increases rapidly from year to year. The article that publishes the most on this topic is Research Articles with the publisher’s name Procedia Computer Science as many as 2662 documents. Meanwhile, the author who published the most on this topic was Yusof, Yudariah Mohammad, until May 28, 2021. The most dominant issue that appears was “communication”, followed by the topic of “systems” and “students”. Network visualization shows that a line demonstrates the relationship between issues between the descriptors in each field. The more relationships between the lines indicate the closer relationships between documents.ch on that topic.: Indicate the main conclusions or interpretations.

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1. INTRODUCTION

Communication is one of the most important abilities in everyday life because communication is a way of sharing and can clarify an understanding (Batubara, Saragih, Simamora, Napitupulu, & Sari, 2022). Through communication, mathematical ideas can be conveyed in the form of symbols, notations, graphs, and terms (Maisyarah & Surya, 2017), (Mushlihuddin & Wahyuni, 2017). Mathematical communication is also a tool that can be used to solve mathematical problems. According to the Dictionary of Indonesian, communication is the sending and receiving of messages between two or more people so that the message in question can be understood (Batubara, Nur, Lubis, & Arianto, 2021). But there are some experts who put forward their opinion on communication, among others: a. Mathematical communication skills are the ability to convey mathematical ideas as well as the ability to understand and accept other people’s mathematical ideas carefully, analytically, critically, and evaluatively to sharpen understanding (Syukri, Marzal, & Muhaimin, 2020). b. Communication is the process of conveying information, ideas, emotions, expertise, and others through symbols such as words, images, numbers, and others (Rahmy, Usodo, & Slamet, 2019). c. Communication is the act of carrying out contact between the sender and the recipient, with the help of messages; the sender and receiver have some experience together that gives meaning to messages and symbols sent by the sender, and received and interpreted by the recipient (Nuraida & Amam, 2019), (Dachi & Batubara, 2020).

Bibliometrics analysis or methods (bibliometrics) are sometimes also referred to as scientometrics which is part of the research evaluation methodology, and from various literature which has been widely generated, allowing the implementation of bibliometric analysis with using a separate method (Ellegaard & Wallin, 2015), (Dolhey, 2019). One of the uses of this bibliometric analysis is to map a research topic with certain keywords, abstracts, or titles that have been carried out by various researchers from all over the world (Md Khudzari, Kurian, Tartakovskv, & Raghavan, 2018), (Tibaná-Herrera, Fernández-Bajón, & De Moya-Anegón, 2018).

Research using bibliometric methods can also reveal the fact that there are still many uncited studies, recent research trends, and so on (Khalil & Gotway Crawford, 2015), (Donthu, Kumar, & Pattnaik, 2020). Bibliometric mapping would benefit either the scientific community as well as the public in general because it can help turn publication metadata into maps or visualizations through VosViewer, which is easier to manage to process in order to gain useful insights, for example visualizing keywords to identify research themes or clusters in certain disciplines, mapping author affiliations from specific journals to identify geographic coverage of journals, and map collaborations institutional and international collaboration as part of a framework for identifying emerging technologies (Tanudjaja & Kow, 2018), (Galvao, Mascarenhas, Marques, Ferreira, & Ratten, 2019).

Basically, bibliometric studies have a positive impact on various matters related to scientific literature, including the identification of literature, the direction of research symptoms and the growth of knowledge in various different disciplines, suspecting the breadth (comprehensiveness) of secondary literature, recognizing the authorship and direction of symptoms in documents various subjects, compiling pad arak documents appropriately and regularly, examining obsolescence and dissemination of scientific literature, knowing research gaps and enriching the amount of research for the field of information science, and being able to develop library collections in a more directed manner (Irianti, 2016). All bibliometric studies are carried out to determine the mapping of research (Batubara, Sari, et al., 2022).

Mapping is a process that allows a person to recognize an element’s knowledge as well as its configuration, dynamics, mutual dependence, and interaction. Knowledge mapping used for technology management purposes, includes program definitions research, decisions concerning activities related to technology, the design of base structures knowledge, as well as the creation of educational and training programs. In relation to bibliometrics, the mapping of science is a method of visualization of a field of science. This visualization can be done with the help of VosViewer software and is done by creating a map of the relationship between one topic and another, one keyword with
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Another keyword, and so on (Sweileh, Al-Jabi, Zyoud, & Sawalha, 2018). On the map will appear topics from science. The inputs are bibliographic data, keywords, citations, etc.

Bibliometric mapping using the VosViewer application will benefit both the scientific community as well as the public in general because it can help change the metadata of publications into maps or visualizations, which are easier to manage to process in order to gain insights which is useful, for example visualizing keywords to identify research themes or clusters in a particular discipline, mapping author affiliations from specific journals to identify the geographic scope of journals, and mapping institutional collaborations and collaborations international as part of a framework for identifying emerging technologies (Tanudjaja & Kow, 2018). However, to map hundreds of journals from various countries, look for the relationship of one keyword with another keyword in the title and abstract of hundreds or even thousands of journals are a silly or futile way if done manually. This reason makes researchers interested in seeing maps or the relationship between Mathematics Communication and Keywords in other titles / abstracts from thousands of articles around the world that have published about “Mathematics Communication” based on data taken from Science Direct. Research on Mathematics Communication has been done a lot by experts both in the field of mathematics and in other sciences. Mathematics Communication that will be studied in this study is to map what has been studied related to Mathematics Communication both from education, lecturers, students, and from non-education.

2. METHODS

This research is a bibliometric literature study of the research development map on the topic of Mathematics Communication which is carried out with the help of the VosViewer application. Broadly speaking, this study was carried out by searching through the Science Direct database (https://www.sciencedirect.com/) uses the term or keyword Open access and Mathematics Communication Through the search field "Document Search". Then the document that appears will be downloaded and stored in a form of Research Information Systems (RIS) file. A RIS file is a bibliographic citation file saved in a format developed by Research Information Systems. This file contains a series of lines delimited by a two-character code and the corresponding values. RIS files provide information such as title, author, publication date, keywords, publisher, issue number, and start and end pages. For this Study, the RIS files are retrieved and what will be analysed is a RIS file related to "Mathematics Communication" either in the research title, Abstract or Keywords.

Furthermore, the RIS data will be analysed using the help of Vos Viewer. VosViewer will analyze the data and categorize the RIS data taken from thousands of such journals to be categorized into several research clusters on Mathematics Communication. The result will be presented in the form of visualization of hundreds of articles based on clusters, relationships, or relationships of communication mathematics keywords with others that appear in the research that has been carried out. Term or research topic that is rarely studied that is still related to the topic of "Mathematics Communication" either directly or indirectly direct (Fahimnia, Sarkis, & Davarzani, 2015).

3. FINDINGS AND DISCUSSION

Published Year Development of Research "Mathematics Communication"

The results of a search through a Science Direct search show that the development of research on "Mathematics Communication" towards Open access has existed since 1997. In that year as many as 448 documents could be accessed via the internet more easily than from year to year, it increased rapidly to the position of 956 documents in 2010 and as many as 1468 documents in 2021 as of May 28, 2021. For more details on the map of the development of Mathematics Communication research from year to year can be seen in the table below:
Table 1. Development of Mathematics Research Communication By Year

| Year | Number of Document | Year | Number of Document |
|------|--------------------|------|--------------------|
| 2021 | 1468               | 2008 | 789                |
| 2020 | 2200               | 2007 | 782                |
| 2019 | 1807               | 2006 | 812                |
| 2018 | 1712               | 2005 | 612                |
| 2017 | 1484               | 2004 | 300                |
| 2016 | 1681               | 2003 | 308                |
| 2015 | 2273               | 2002 | 185                |
| 2014 | 1673               | 2001 | 182                |
| 2013 | 1497               | 2000 | 210                |
| 2012 | 1686               | 1999 | 332                |
| 2011 | 1298               | 1998 | 446                |
| 2010 | 956                | 1997 | 448                |
| 2009 | 825                |      |                    |

From the table, it can be seen that the map of research developments every year continues to increase. This indicates that the topic of Mathematics Communication is very important to study and has many benefits and relationships with other disciplines.

Types of Articles That Contain "Mathematics Communication" on the Research Development Map

As for the Type of Article that has been published about "Mathematics Communication both a title, abstract, keyword, and content can be seen in the table below:

Table 2. Types of Articles that Contain “Mathematics Communication”

| Type of Articles   | Number of Document | Type of Articles   | Number of Document |
|--------------------|--------------------|--------------------|--------------------|
| Review Articles    | 1500               | Editorials         | 249                |
| Research Articles  | 27073              | Errata             | 37                 |
| Book Chapters      | 2                  | Mini-Reviews       | 177                |
| Conference Abstracts| 358                | News               | 35                 |
| Book Reviews       | 378                | Practice Guidelines| 10                 |
| Case Reports       | 6                  | Product Reviews    | 1                  |
| Conference Info    | 46                 | Short Communication| 904                |
| Correspondence     | 67                 | Software Publications| 26                |
| Data-Articles      | 34                 | Others             | 1336               |
| Discussion         | 85                 |                    |                    |

From the table above, it can be seen that the highest number of documents discussing Mathematics Communication is Research Articles with 27073 documents followed by Review Articles with 1500 documents.

The Name of the Journal That has been Published about "Mathematics Communication"

The names of publications that have been published about "Mathematics Communication both as a title, abstract, keywords, and content can be seen in the table below:
Table 3. Name of the Journal that Contains “Mathematics Communication”

| Name of Journal                                      | Sum  | Name of Journal                                      | Sum  |
|------------------------------------------------------|------|------------------------------------------------------|------|
| Procedia Computer Science                             | 2662 | Journal of Computational and Applied Mathematics     | 560  |
| Procedia Social and Behavioral Sciences               | 2113 | Linear Algebra and its Applications                  | 529  |
| Theoretical Computer Science                          | 1303 | Journal of Mathematical Analysis and Applications    | 451  |
| Discrete Mathematics                                  | 1227 | Journal of Biological Chemistry                      | 398  |
| Computer & Mathematics with Applications              | 1189 | Journal of Computer and System Science               | 335  |
| Discrete Applied Mathematics                          | 1147 | Science of Computer Programming                      | 327  |
| Procedia CIRP                                         | 1039 | Energy Procedia                                      | 296  |
| Mathematics and Computer Modelling                    | 755  | Transportation Research Procedia                     | 291  |
| Procedia Engineering                                  | 686  | Information and Control                              | 281  |
| Electronic Notes in Theoretical Computer Science      | 670  | Applied Mathematics Letter                           | 277  |
| Biophysical Journal                                   | 618  | Journal of Dairy Science                             | 273  |
| Procedia Manufacturing                                 | 598  | Stochastic Processes and Their Applications          | 266  |
| Applied Mathematics Modelling                         | 576  |                                                      |      |

From the table above, we can conclude that the name of the publisher that publishes the most Mathematics Communication is Procedia Computer Science with 2662 documents followed by Procedia Social and Behavioral Sciences with 2113 documents. All of the data was obtained using a “Science Direct” search with the keyword “Mathematics Communications” with Open access.

Map of Mathematics Communication Co-Author
After conducting a subject analysis to determine the field of each Mathematics Communication research map through science direct tracing with Open access, it was found that several authors wrote a lot about Mathematics Communication from thousands of journals with criteria of at least 5 journal documents that had been written and published. As a result, there are only 13 authors who write articles on Mathematics Communication with the criteria for articles written by at least 5. The names of these authors along with the number of documents that have been written about Mathematics Communication (Minimum 5) with a total link are shown in the figure below:
From the picture above, it can be seen that the author on behalf of Yusof, Yudariah Mohammad is the author of the most authors about Mathematics Communication which is traced from Data Science Direct with Open access. While the author who has the most network is Suradi, Nur Riza Mohd.

Visualization Network Author Mathematics Communication

From the results of searching the Science Direct database with the Type Open access, researchers downloaded 1000 documents then exported them into RIS format, inputted, and analyzed them using VosViewer. From the results of the analysis obtained in the results of network visualization as many as 13 authors. The network Visualization of the co-author is shown in the figure below:

From the image above, it can be seen that there are several authors who have links with one another. But there are also those who have no links at all. The most numerous links are indicated by the image of the largest coil called cluster 1. If cluster 1 is enlarged it will look like the image below:
From the picture above, it appears that cluster 1 consists of 21 authors, and all authors have links to each other. Overall, it is known that there are 15 clusters in total with 225 links and 679 link strengths.

Topics of Research Development in Mathematics Communication

After an analysis of documents that have been stored in the form of RIS, 79 research topics were found that most often appeared. But the author only wrote down 25 topics that appeared most frequently out of the 79 topics. The topic can be seen in the table below:

Table 4. Research Topics on Mathematics Communication

| Keywords                  | Occurrence | Percentage |
|---------------------------|------------|------------|
| algorithm                 | 253        | 2.84       |
| network                   | 373        | 2.22       |
| patient                   | 81         | 1.56       |
| case                      | 132        | 1.45       |
| school                    | 140        | 1.43       |
| teaching                  | 123        | 1.42       |
| mathematical model        | 213        | 1.39       |
| number                    | 178        | 1.16       |
| Mathematics               | 480        | 1.05       |
| student                   | 598        | 1.03       |
| teacher                   | 326        | 1.01       |
| system                    | 633        | 0.96       |
| learning                  | 195        | 0.93       |
| education                 | 193        | 0.91       |
| child                     | 80         | 0.79       |
| time                      | 210        | 0.77       |
| model                     | 580        | 0.75       |
| Communication             | 746        | 0.59       |
From the table above, it can be seen that there are 25 topics that most often arise from thousands of topics. These topics appear at least 29 times. If a topic only appears under 29 times, then it is automatically eliminated. The topic that most often appears is "Communication" 746 times followed by "system" 633 times and "student" 598 times.

Visualization of Network Topics in Mathematics Communication

Based on the results obtained in table 4 above, the results of the visualization of the 79 topics after being processed using VosViewer can be seen in the figure below:

![Figure 4. Visualization of Network Topics in Mathematics Communication](image)

Figure 4 above, shows that the mathematics communication research development map is divided into 3 main clusters. The clusters are marked with three color fruits that appear in the image. The explanation of the three clusters is Cluster 1 red color consists of 38 topics including algorithm, application, Communication, Communication complexity, Communication network, Communication system, efficiency, framework, model, group, operation, function, graph, evolution, and network. Cluster 2 green color consists of 30 items including activity, attitude, case study, mathematics education, education, course, Communication skills, researcher, school, learning, mathematics, knowledge, computer, participant, and question. Cluster 3 blue color consists of 11 topics, namely base, Communication technology, control group, difference, effect, group, ICT, level, mathematical model, mathematical modeling, and patient.

Visualization of Density on the Topic of Mathematics Communication

Density is an item (label) that is marked the same as the visible item. Each item point has a color that depends on the density of the item that appears on the image. It identifies that the color of the dots
on the map depends on the number of items associated with other items. This section is very useful for obtaining an overview of the general structure of bibliometric maps by paying attention to the parts of the items that are considered important for analysis. Through the results in this image, we can interpret the most used and most researched keywords. Vice versa, by utilizing the Visualization of topics in this section of density, we can find out which topics are rare or the least researched. The visualization of the density of the co-word map of the development of Mathematics Communication research can be seen in the following figure:

Figure 5. Density Visualization of Mathematics Communication

The figure shows a map of density between research topics which is the result of VosViewer analysis of all Mathematics Communication articles with Open access in the Science Direct database, both related and unrelated directly. From the picture, it can be explained that the map of the development of Mathematics Communication research by utilizing VosViewer as a bibliometric data analysis tool brings up the word “Communication” with the largest font and the most yellow color. This explains that the larger the font that appears on the image and the more yellow the color that appears in the image indicates that the density is denser which means that the topic is widely researched. Conversely, if the color is dimmed, and the font is getting smaller, it indicates that the topic has not been researched much.

4. CONCLUSION

Based on the results and discussion above, it can be concluded that the development of research on Mathematics Communication towards Open access has existed since 1997. Since then, the topic of this research has grown rapidly until 1468 documents in 2021 as of May 28, 2021. The articles that discuss the most about the topic are articles with the type of Research Articles with the keywords Open access and Mathematics Communications with the name of the publisher Procedia Computer Science as many as 2662 documents followed by Procedia Social and Behavioral Sciences as many as 2113 documents. All of the data was obtained using the search “Science Direct” with the keyword “Mathematics Communications” through Open access with Yusof, Yoda Mohammad as the author who wrote the most articles on the topic.

From the thousands of documents that have been analyzed, it is known that the author has 21 other authors who both publish on the topic. All of these authors have a network (links) between each other and overall, it is known that there are a total of 15 clusters with 225 links and 679 link strength. The field or word that most often appears from thousands of documents is “Communication” 746 times followed by “system” 633 times and “student” 598 times. Through network visualization, it shows that
the relationship between research topics is shown with lines between descriptors in each field. The more lines of relationship between descriptors, the closer the relationship between the documents will be. Meanwhile, the visualization of density shows that the relationship between topics is getting yellower, the tighter it will be and the greener it will be, the less it will be researched.

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