BIBLIOMETRIC ANALYSIS: GOOGLE CLASSROOM ON MATHEMATICS LEARNING IN THE SCOPUS DATABASE USING VOSVIEWER

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Abstract

The Covid-19 pandemic has changed the global education paradigm, including in Indonesia which has adopted distance learning to avoid the spread of the virus. In this context, the use of the google classroom digital platform has become very relevant. This study explores the development and publication trends related to the use of google classroom in mathematics learning from 0-2024 years. By utilizing the Scopus database and Publish or Perish software, the analysis showed a significant spike in the number of 121 documents, through the results of screening into 100 articles using the DOI format. 2021 recorded the highest number of citations, with Indonesia as the leading country and Indonesia University of Education as the top institution. University College London recorded the highest number of citations, while the Journal of Physics: Conference Series dominated the publication. Author Dadang Juandi ranked first, while Melissa Bond received the highest citation for an article on "Facilitating Student Engagement Through the Flipped Learning Approach in K-12". Bibliometric analysis using VOSviewer identified 13 keyword clusters with new themes such as learning style, game-based learning, and numerical analysis that emerged as potential research topics. The study also highlights analytical challenges such as data limitations and difficulty in interpreting results. Cross-agency and international collaboration is expected to encourage innovation in this field.

Keywords: Bibliometric Analysis, Google Classroom, Mathematics Education, Scopus, VOSViewers

1. Introduction

The Covid-19 pandemic has limited various human activities and affected almost all countries. Education from preschool to university is now implementing online learning using electronic devices and digital platforms. Advances in media technology today play a crucial role in supporting the effectiveness of distance learning (Anggoro et al., 2021). With the creative and innovative use of media, teachers can convey material well and achieve learning goals (Fadzillah et al., 2022). Useful learning media in the teaching and learning process can generate new desires, interests, and motivation for students (Septiani et al., 2024).

According to the Indonesia Survey Flow survey, Google Classroom be platform is the most popular for online learning, with a usage percentage of 26.1%. This was followed by the Teacher's Room (17.1%) and the Learning House (15.2%). Google classroom It is considered effective because it provides structured virtual learning, facilitates interaction between teachers and students, and makes it easier to manage assignments and collaboration. Integration with various learning methods also supports the success of the educational process (Natalia & Kristin, 2021). This platform ensures

that learning activities continue to run well even in challenging situations (Marbun & Sinaga, 2021). Use Google Classroom During the pandemic it proved to be very effective in improving students' skills and discipline, meeting the government's requirements to continue the teaching and learning process.

Mathematics is an important basic science because it underlies the development of knowledge and technology and helps build critical and creative thinking. Ability in mathematics is the main capital to master various fields of science and technology (Jamil et al., 2021). Learning mathematics not only trains numeracy skills, but also teaches logical thinking. According to (Ekawati et al., 2019) Mathematics essentially develops the ability to think on the basis of reason and reasoning, so students can improve their analytical and logical skills. The use of technology in the creation of learning media can be a very useful tool for the development and improvement of the quality of education (Anggoro et al., 2019). To make it easier to understand mathematics, teachers need to use creative teaching methods and various learning media, not just relying on printed books.

Research on the use of Google Classroom In mathematics learning, a lot has been done, but a review of bibliometric literature on this topic is still rare. This review aims to evaluate the progress and trends of research related to the use of Google Classroom in mathematics education. The term bibliometric in Indonesian, known as "bibliometrics" in United Kingdom, derived from two words "biblio" and "metrics". Etymologically, "biblio" means book, while "metrics" means measurement. Therefore, bibliometrics refers to the method of measuring and analyzing data related to books or scientific literature to assess the developments, trends, and impacts of research in a field (L. Hakim, 2020). Bibliometric research is a research method that has been used for a long time in library and information science. (Muntazhimah et al., 2022). The main purpose of bibliometrics is to explain written communication in the scientific field and understand the development of research. It includes analysis of publications, citations, and collaborations, as well as helping to identify trends, relationships of scientific work, and research impacts across different disciplines (Habibi et al., 2022).

The researcher conducted a bibliometric study using a database Scopus with the help of VOSviewer software. VOSviewer is a software used to create network data-based maps and to visualize and explore those maps (Rostiany & Tjandra, 2022). VOSviewer used for its ability to work effectively with large data sets and provide a wide range of visualizations, analysis, and investigations (Kurnia et al., 2023). By applying the bibliometric method and VOSviewer software, researchers can identify keyword groups, author developments, institutions, publications, countries, and promising future research directions (Sudirjo et al., 2023).

Some of the research that has been conducted and related to this research is carried out (Julianis et al., 2023) The results of the study show a significant increase in the number of articles on the use of ICT since 2017. The study identified four main themes"Memory Aid" "Effectiveness" "Grade" and "Mathematics Education" The goal is to analyze writing trends, most citations, journal rankings, journal country of origin, and mapping using CSV format. The current research aims similarly but adds an analysis of bibliographic pairs of documents and authors, using different keywords and DOI formats. Research conducted (Wahyuni & Sartika, 2022) The results of the study show that the use of Google Classroom in mathematics learning significantly increases the effectiveness of teaching, with high student participation and positive attitudes shown by students. This study uses the Systematic Literature Review (SLR) and

databases Google Scholar. The researcher currently aims to analyze by bibliometric method using a database Scopus.

2. Theoretical Background

The selection of bibliometric type databases and publication identification are the keys to the reliability of bibliometric indicators. This research uses a database Scopus and tools Publish or Perish for analysis. Scopus is one of the databases with strict selection in assessing the quality of journals. According to (Utoro & Rosadi, 2022) Scopus Evaluating journals annually uses predetermined criteria, such as the number of articles, citations, and average citations per article, to determine the journal's index. Database Scopus chosen for its internationally recognized quality and reputation, both by universities and research institutes (L. Hakim, 2020). Data from Scopus Often used by researchers as a reliable reference to analyze or discuss research results. Software Publish Or Perish (PoP) is a software program that retrieves and analyzes academic citations using various sources (Hudha et al., 2020).

Based on the background of the problem and the focus of the research that has been presented, the formulation of the problem is as follows: (1) How is the development of research on the use of google classroom media in mathematics learning (2) How is the visualization of bibliometric mapping of networks between keywords in the research on the use of google classroom media in mathematics learning (3) How are the recommendations for future research opportunities related to the use of google classroom media in mathematics learning (4) What are the impacts and challenges of future research related to the use of google classroom media in mathematics learning, and from the results of this study aim to analyze the number of publication developments, visualization of bibliometric mapping of networks between keywords, Recommendations for opportunities, and see the impact of future research related to the use of Google Classroom media in mathematics learning in the Scopus database from 2007-2024 with a deadline of June 13, 2024.

3. Methods

This study uses a descriptive quantitative method with a bibliometric approach to provide a systematic, factual, and accurate description of the events or phenomena being studied, as well as present comprehensive information about the data population (Rukajat, 2018). According to (Zahro et al., 2023) the bibliometric approach is used to assess the influence of a field's research over time to determine the relationship between influence and impact as well as engagement and relevance to published documents. Meanwhile, according to (Merigó Lindahl et al., 2019) the bibliometric analysis approach uses standards such as publication productivity, research topic, authors, institutions, and countries for analysis. This method aims to understand the development of Google Classroom in mathematics learning, identifying research gaps, and discovering new aspects for future studies.

According to (Van Eck & Waltman, 2022) VOSviewer provides three map visualizations, namely Network Visualization, overlay visualizationand density visualization. According to (Orduña-Malea & Costas, 2021)VOSviewer provides excellent case studies for testing proposed methods and is a widely known and relevant software among the scientific community. VOSviewer can be used to build networks in various aspects of scientific publications, including scientific journals, researchers, author organizations, events, citations, as well as bibliographic relationships or Co-

citation (Van Eck & Waltman, 2022). According to (Hudha et al., 2020) Data analysis in this study is carried out through several stages, namely determining search keywords, initial search results, narrowing search results, compiling statistical data, and data analysis.
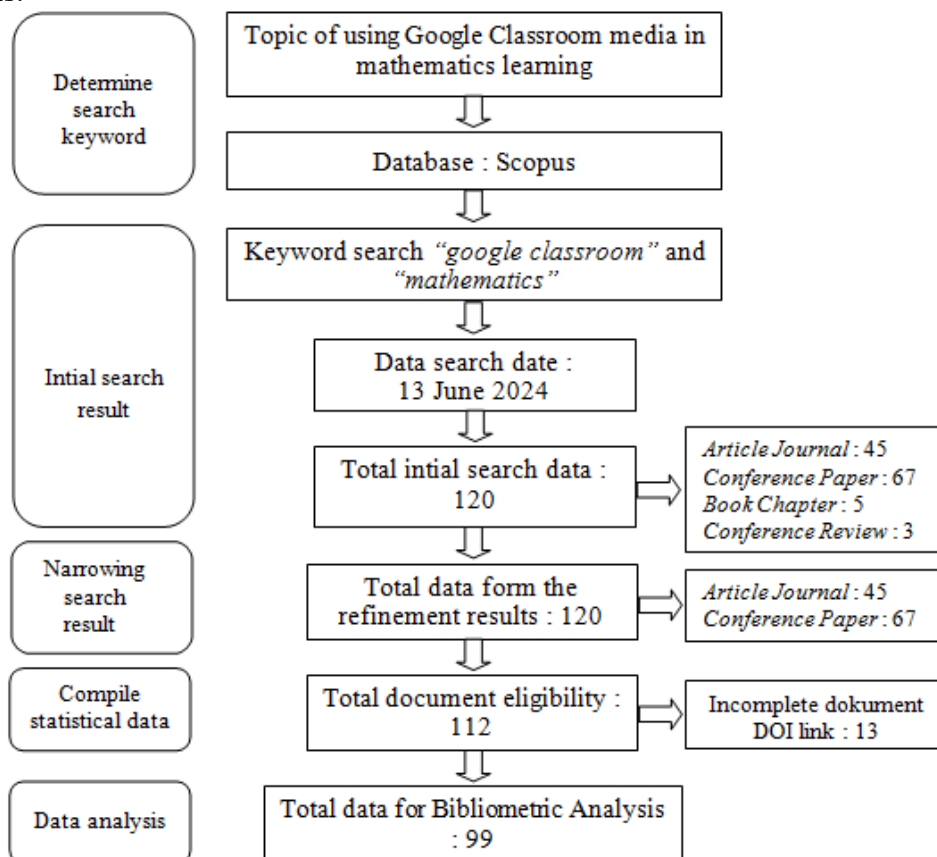

Figure 1. Image of the stage of bibliometric analysis

Metadata collection is done by searching the database Scopus Using the Software Harzing's Publish or Perish (PoP). At Scopus Database at software publish or perish (PoP) A maximum of only 200 documents can be obtained. The metadata search of this research was conducted on June 13, 2024, the year range 0-2024 with the keyword "google classroom" and "Mathematics", The initial data search contained 121 documents. Then the results are compiled in the Research Information System (RIS) format, then the documents in the screening according to the criteria in this study, namely: (1) the data used is in the form of Type Article Journal and Conference Paper. (2) The selected data was taken from a span of 17 years, namely in 2007-2024 with a limit of June 13, 2024. (3) the article is written in United Kingdom, and (4) the article data has a link Digital Object Identifier (DOI). After going through the stage screening There are 100 documents to analyze.

Next, the DOI link of the filtered article is entered into the Notepad software. The use of DOI makes it easier to manage digital resources, especially related to copyright and intellectual property rights, as well as facilitate the tracking of the existence of scientific works and the discovery of complete data of documents. The filtering results that have been obtained in DOI format are then imported into VOSviewer. In this study, VOSviewer was used to analyze the type of bibliographic coupling and co-occurrence with the analysis unit covering documents, authors, sources, organizations, and countries. The number of publications each year can be seen in the figure below.
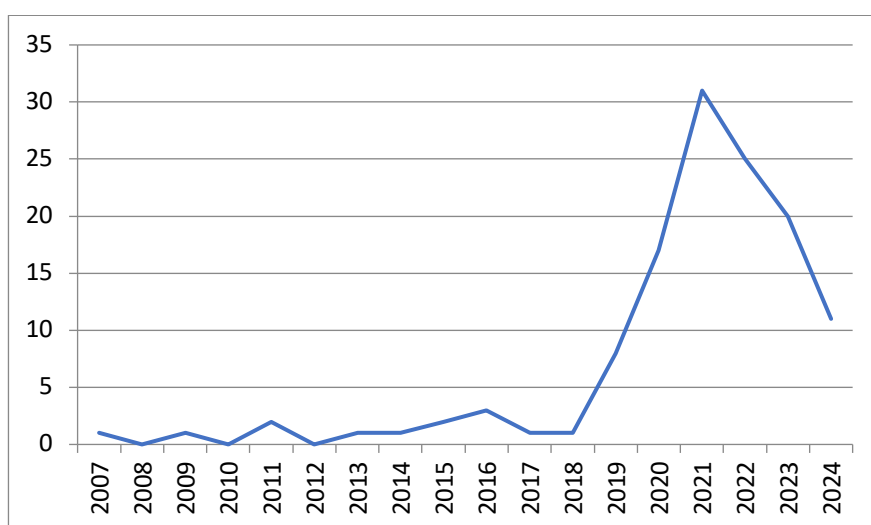
Figure 2. Graph of Number of Publications Per Year

However, after the researcher limited and narrowed the keywords "google classroom" and "mathematics" the number of publications indexed in Scopus to 100 publications, as shown in the table below.

Table 1. Number and Percentage of Publications

	Year of Publication	Number of Publications	Percentage
1	2024	10	10,0%
2	2023	16	16,0%
3	2022	17	17,0%
4	2021	28	28,0%
5	2020	15	15,0%
6	2019	7	7,0%
7	2018	1	1,0%
8	2017	0	1,0%
9	2016	1	1,0%
10	2015	3	3,0%
11	2014	1	1,0%
	Total	99	100,0%

Development of international publications on the use of Google Classroom In mathematics learning, as shown in Table 1 and Figure 2, it shows an increase from 2007 to 2024, with the highest growth recorded in 2021 (28 publications or 28.0%). In 2022, there were 17 publications (17.0%), in 2023 with 16 publications (16.0%), and until June 13, 2024, there were 10 publications (10%). Documents in the database Scopus It is often used as a reference or citation in other research, which shows that the more citations a document has, the more often the research results from that document are used as a reference. Therefore, researchers use the number of publications and the number of documents as the basis for sorting institutions and journals.

4. Results and Discussion

This research was analyzed and visualized using descriptive bibliometric analysis methods. The researcher applies a deductive approach in presenting the results of the analysis. The presentation of the results of bibliometric analysis is carried out in a deductive way, starting from general findings to more specific findings, such as

bibliographic pairs of countries, institutions, journals, publications, authors, and co-occurrence of keywords. This way, readers can follow the information from the general to more specific details.

4.1 Country Bibliographic Pairs

To display the results of country bibliographic pairs in the VOSviewer software, the researcher sets a minimum number of documents that a country must have. The researchers determined that each country must have at least 1 document in order to be displayed in the network visualization. There are publications from 30 countries involved. Here are the top five countries shown, as seen in the table below.

Table 2. Countries with the Highest Number of Documents/Citations

	Country	Documents	Citations	Total Link Strength
1	Indonesian	38	467	135
2	United States	9	69	32
3	China	3	60	94
4	Chile	3	17	183
5	Norway	2	12	165

Based on table 2, the ten countries with the highest number of documents are Indonesia, which has 38 documents with 467 citations. Chile is in first place with a total link strength of 183, has 3 documents and is cited 60 times. Furthermore, the pattern of cooperation between countries will be analyzed and displayed using the VOSviewer software.
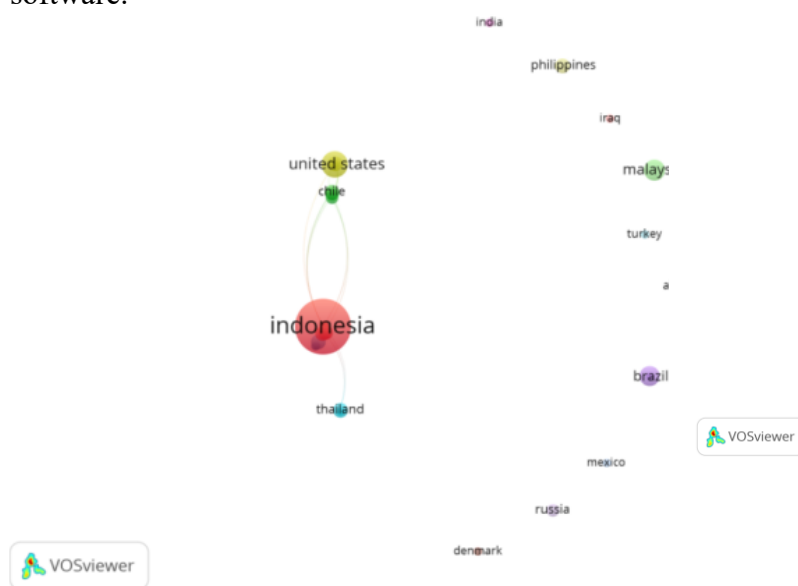

Figure 3. Network visualization of bibliographic pairs of countries

Figure 4. Visualization of the largest cluster of country bibliographic pairs

In Figure 3, it can be seen that there are 30 countries grouped in various colors, which indicates the existence of clusters or groups of countries. The largest cluster is marked in red, followed by clusters in red, green, blue, yellow, purple, and others. In figure 4, countries such as Indonesia, China, Italy, Japan, South Africa, and the United Kingdom are included in the red cluster, which is the largest cluster. This shows that these countries often collaborate in research on the use of google classroom in mathematics learning. The country of Indonesia has a larger circle diameter than other

countries in the red cluster, which indicates that the country has a larger number of documents.

4.2 Bibliography Pairs of Institutions

Documents indexed in Scopus related to Google Classroom and mathematics are published by various institutions or universities. The five institutions with the highest number of documents, along with the number of citations and total link strength, are shown in the table below.

Table 3. Institution with the Highest Number of Documents/Citations

No	Organization	Documents	Citations	Total link strength
1	Indonesia University of Education	7	67	109
2	State University of Semarang	6	25	32
3	University of Jember	4	44	31
4	University of Collage London	1	215	68
5	Raden Intan State Islamic University Lampung	1	131	68

Based on the table above, the trend of the institution with the highest number of citations in this study shows that Indonesia University of Education is at the top with 7 documents and a total link strength of 109. Meanwhile, the university with the highest number of citations is University College London, which has 215 citations. The mapping of the university will be displayed in the network visualization, as seen in the image below.

Figure 4. Network visualization of institutional bibliographic pairs

Figure 5. Visualization of the largest cluster of institutional bibliographic pairs

From figure 4 above, there are 99 universities it can be seen that Indonesia University of Education has a large circle diameter. Based on the colors shown, there are several clusters in this university bibliography pair. There are 58 clusters with different colors. In the figure, the 5 largest clusters, the red ones include 9 universities, namely: Indonesia University of Education, Al-Qasemi Academic College of Education, An-Najah National University, Guangxi Normal University, Siliwangi University,

Universidade De Vigo, General Ahmad Yani University, University of Warwick, and Université Sultan Moulay Slimane.

4.3 Journal Bibliographic Pairs

Documents indexed in Scopus regarding google classroom and mathematics are published in various journals. After collecting the documents, the researcher used the VOSviewer application to analyze the bibliographic pairs of journals and sort the journals based on the number of documents. The five journals with the highest number of documents are presented in the following table.

Table 4. Journal with the Highest Number of Documents/Citations

No	Source	Documents	Citations	Total link strength
1	Journal of Physics: Conference Series	28	179	23
2	Aip Conference Proceedings	19	9	23
3	Education Sciennces	3	101	2
4	Heliyon	1	57	16
5	Computers and Education	1	215	9

Based on Table 4 above, the trend of journals with the highest number of documents regarding google classroom and mathematics shows that Journal of Physics: Conference Series is at the top of the ranking with 28 documents and a total link strength of 23. The Journal of Computers and Education has the highest number of citations, which is 215 citations. This suggests that the results of this study are in line with the focus and scope of these journals, so this information can be a useful reference for researchers who want to publish their research in this field.

Figure 6. Network visualization of journal bibliographic pairs

Figure 7. The largest cluster network visualization is a bibliographic pair of journals

From figure 6 above, there are 41 journals that each have at least one document. Based on color, there are 30 different clusters. In the figure, the 7 largest clusters, which are marked in red, include 4 items, namely AIP Conference Proceedings, Eurasia Journal of Mathematics Science and Technology Education, Heliyon, and Smart Innovation Systems and Technologies.

4.4. Bibliography Pairs Documents

Articles that have been published in various journals and indexed in Scopus have a varying number of citations, with some articles reaching up to 178 citations. Table 5 below shows a list of the top articles that researchers obtained from the Publish or Perish software.

Table 5. List of Highest Cited Articles

No	Cites	Authors	Title	Year	Source
1	215	M. Bond	Facilitating student engagement through the flipped learning approach in K-12: A systematic review	2020	Computers and Education
2	131	R. Ramadhani	The effect of flipped-problem based learning model integrated with LMS-google classroom for senior high school students	2019	Journal for the Education of Gifted Young Scientists
3	177	M. Irfan	Challanges During The Pandemic: Use Of E-learning In Mathematics Learning In Higher Education	2020	Infinity Journal
4	57	C. Lathwesen	Escape rooms in stem teaching and learning prospective field or declining trend: A literature review	2021	Education Sciences
5	52	B. Chirinda	Teaching mathematics during the COVID-19 Lockdown in a context of historical disadvantage	2021	Education Sciences

In Table 5, the study by M. Bond recorded the highest number of citations compared to others. The article discusses "Facilitating Student Engagement Through the Flipped Learning Approach in K-12: A Systematic Review." This article is widely cited for showing that the reverse learning approach favors student engagement, with many studies noting the behavioral, affective, or cognitive aspects of students. Collaborative technologies such as Google Classroom, Google Docsand edmodo is associated with increased engagement, while videos that are not produced by teachers can lead to a lack of student engagement. Future research is suggested to pay attention to contextual information, data collection methods, and theories used, as well as involve the perceptions of parents, teachers, and school leaders, as well as conduct longitudinal and multi-class research.

4.5 Author's Biography

The author's bibliographic pairs are shown in table 6 shown with overlay visualizations. The researcher uses the threshold at this stage, which is the minimum number of publications from an author, namely 284 publications.

Table 6. Author with the Highest Number of Documents/Citations

No	Author	Documents	Citations	Total Link Strength
1	Dadang Juandi	4	64	391

2	Maximus Tamur	2	60	327
3	Rahmi Ramadhani	2	149	240
4	Melissa Bond	1	215	26
5	Abdurrahman	1	131	106

In table 6, Dadang Juandi is in first place with a total link strength of 391 and 4 documents. Meanwhile, the author with the highest number of citations is Melissa Bond, who has 189 citations. This shows that in addition to publishing the most journals related to this research, Dadang Juandi is also actively collaborating with other authors.

Figure 8. Network visualization of author bibliographic pairs
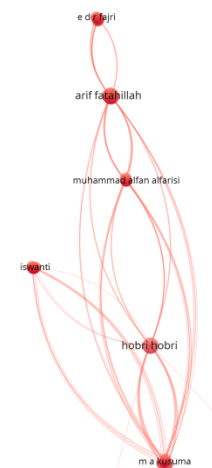
Figure 9. Visualization of the largest cluster of networks against author bibliographic pairs

In figure 8 above, the data is displayed through overlay visualizations with various colors such as red, blue, green, and others. These colors indicate a network of articles related to the published author. In the figure 9, the red cluster indicates the most author collaborations with 18 items, which include: Arif Fatahillah, Edr Fajri, Hobri, Iswanti, La Monalisa, Ma Kesuma, M. Fatekurrahman, Muhammad Alfan Alfarisi, Muhlasah Novitasari Mara, Hadiyanti, Nur Hasanah, Rafiantika Megahnia, Rafly Prasetyo, Randi Pratama, Saddam Hussen, Sri Suryanti, Suko Raharjo, and Susanto.

4.6 Joint Emergence of Keywords from Authors

In the author's keyword co-event analysis, the researcher set a threshold that each keyword should have at least 1 event along with 344 other keywords. The occurrence of this keyword can be seen in the following image.

Table 7. Occurrence of Highest Cited Keywords

No	Keyword	Occurences	Total Link Strength
1	Mathematics Education	86	1100
2	Computer Science	81	1044
3	Psychology	70	948
4	Multimedia	42	522
5	Pedagogy	37	465

In table 7 above, the keyword Mathematics Education recorded the highest number of co-occurrences, with 86 co-occurrences and a total link strength of 1100, because this study focused on mathematics learning. In second place is the keyword Computer Science, which has 81 common events and a total link strength of 1044, suggesting that research on math learning is often associated with Computer Science. Next, the keywords published by the network will be displayed as follows.
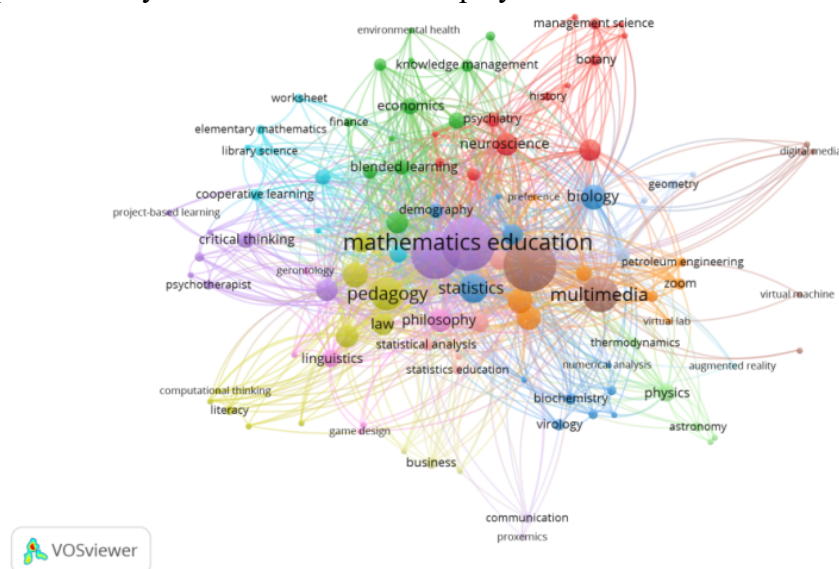

Figure 10. Network visualization of keyword co-occurrence

In figure 10 above, the different colors show 13 clusters. The red cluster is the largest cluster, consisting of 13 keywords, namely anxiety, botany, engineering, ethnomathematics, general partnership, history, management science, mathematical problem, mechanical engineering, metacognition, psychiatry, and psychological intervention. In this cluster, engineering keywords have the largest circle compared to other keywords, indicating that the focus of research in this cluster is on the field of engineering. In addition, engineering keywords have not been connected to game-based learning.
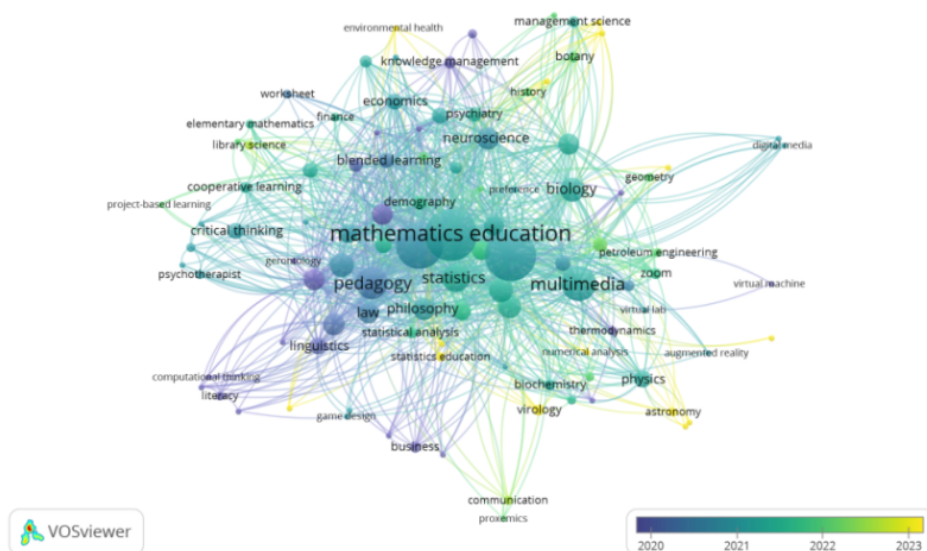

Figure 11. Overlay visualization of keyword co-occurrence

In Figure 11 above, yellow, green, blue, and purple are visible, each representing keywords in documents published in specific years. Yellow shows documents published in 2023-2024. Purple shows publications from around 2007-2020, blue covers 2020-2021, and green covers 2021-2022. From the image, it can be seen that the most recent keywords include Learning Style, Game-based Learning, Environmental Health, Linear Algebra, Metacognition, Psychological Intervention, Mathematical Problem, Astronomy, Earth Science, Geology, Numerical Analysis, Virology, Social Studies, and Statistics Education.

5. Conclusion

The bibliometric study on the use of Google Classroom in mathematics education shows that between 2014 and 2017, there were only 7 documents, while from 2018 to 2024, the number increased to 93 documents, with 2021 recording the highest citation rate. Indonesia became the country with the most citations, and the Indonesia University of Education dominated as the top institution. Meanwhile, University College London recorded the highest number of citations, and Journal of Physics: Conference Series ranked as the leading journal. The author Dadang Juandi ranked first, while Melissa Bond led in terms of citations, with 215 citations for the article "Facilitating Student Engagement Through the Flipped Learning Approach in K-12: A Systematic Review." Analysis using VOSviewer through the network visualization and density visualization menus identified 13 keyword clusters, including anxiety, botany, engineering, ethnomathematics, general partnership, history, management science, mathematical problem, mechanical engineering, metacognition, psychiatry, and psychological intervention. The latest keywords, marked in yellow, include learning style, game-based learning, environmental health, linear algebra, metacognition, psychological intervention, and numerical analysis. These items could become new and innovative themes for future research. Collaboration between countries, institutions, journals, and authors has the potential to enhance knowledge and innovation, and generate new ideas in this field, despite challenges such as data limitations, inconsistent data quality, difficulties in assessing research quality, and the right way to interpret analysis results. The recommendations from this study include using other databases, conducting article analysis with different software such as biblioshiny or hitcite, and updating data to track the growth of published articles each year to assess future research opportunities.

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