Research Trends Mathematics Concepts on Pre-Service Mathematics Teachers: A Bibliometric Analysis Using Vosviewer From 2017 To 2022

Rani Sugiarni[1], Tatang Herman[2], Didi Suryadi[3], Sufyani Prabawanto[4], Sarah Inayah[5]
[1,2,3,4,5] Universitas Pendidikan Indonesia, Bandung, Indonesia
[1,5] Universitas Suryakancana, Cianjur, Indonesia
*Corresponding Author: ranisugiarni@gmail.com

ABSTRAK

Mempersiapkan calon guru yang berkualitas juga membantu menciptakan sistem pendidikan yang berkelanjutan, Oleh karena itu, persiapan calon guru harus menjadi prioritas bagi setiap sistem pendidikan yang ingin mencapai kesuksesan dan berkelanjutan. Beberapa riset calon guru matematika telah berkembang pesat. Studi ini bertujuan untuk menyelidiki: 1) bagaimana analisis kinerja (*performance analysis*) dari metrik terkait publikasi dan kutipan beserta trennya dari studi "*pre-service teacher mathematics*", dan 2) bagaimana pemetaan ilmu pengetahuan dan analisis jaringan (*science mapping and network analysis*) terkait analisis kutipan, analisis mitra kepenulisan dan analisis mitra kata dari studi "*pre-service teacher mathematics*". Metode penelitian ini dengan pendekatan bibliometrik menggunakan basis data Scopus dengan dua kata kunci pencarian yaitu "*pre-service teacher*" and "*mathematics concepts*". Sebanyak 181 dokumen terkait dengan kedua kata kunci tersebut yang tersebar pada rentang tahun 2017-2022. Analisis data dilakukan secara analisis kinerja, pemetaan ilmu pengetahuan dan analisis jaringan menggunakan perangkat lunak Publish or Perish dan VOSviewer. Hasilnya diperoleh bahwa publikasi terkait studi "*pre-service teacher mathematics*" dengan 337 kutipan (sitasi) dari 118 dokumen. Penelitian tentang *pre-service teacher*" dan "*mathematics concepts*" telah berkembang pesat di lima tahun terakhir, antar lain Visualisasi Jaringan kemunculan co-authorship yakni Suryadi dari negara Indonesia. Sedangkan kemunculan Kata Kunci (*co-occurrence*) sering muncul antara lain *teacher knowledge, concept map, professional development, stem education and content mathematics*. Namun, masih terdapat celah bagi kita untuk membuat penelitian baru sebagai pengembangan dari penelitian-penelitian sebelumnya dalam pengembangan calon guru matematika berkualitas.

Kata Kunci: bibliometric; calon guru; konsep matematika,; VOSviewer

ABSTRACT

Preparing qualified teacher candidates also helps to create a sustainable education system, therefore, the preparation of teacher candidates should be a priority for any education system that wants to achieve success and sustainability. Some research on prospective mathematics teachers has developed rapidly. This study aims to investigate: 1) what is the performance analysis of publication and citation-related metrics and their trends from pre-service teacher mathematics studies, and 2) what is the science mapping and network analysis of citation analysis, authorship partner analysis, and word partner analysis from pre-service teacher mathematics studies. A research method is a bibliometric approach using the Scopus database with two search keywords namely "pre-service teacher" and "mathematics concepts". A total of 181 documents related to the two keywords were distributed in the range of 2017-2022. Data analysis was done by performance analysis, science mapping, and network analysis using Publish or Perish and VOSviewer software. The results showed that publications related to the study of "pre-service teacher mathematics" with 337 citations from 118 documents. Research on "pre-service teacher" and "mathematics concepts" has grown rapidly in the last five years, Visualization Network co-authorship emergence is Suryadi from Indonesia.

While the occurrence of keywords (co-occurrence) often appears among others teacher knowledge, concept map, professional development, stem education, and content mathematics. but there is still a gap for us to make new research as a development of previous research in the development of quality pre-service mathematics teachers.

Keywords: bibliometric; mathematics concepts; pre-service teacher; VOSviewer

INTRODUCTION

In preparing the nation's next generation, an important sector is education (Trapsilasiwi, Jhahro, and Setiawan, 2. A good education will produce quality human resources, and this will have an impact on the progress of a nation. Because the role of education is very important and fundamental, all levels of society must pay close attention to it. Education must provide space for a person to develop himself and survive in the midst of a dynamic life (Hidayat, Irvansyah, and Melati, 2023).

Mathematics education is an important part of the world of education because it has many benefits that have a positive impact on students and society as a whole. Mathematics as a core subject is abstract and has its own challenges that are different from other subjects (Atteh, 2020), so it becomes more of a challenge for Mathematics teachers to present learning content in accordance with the curriculum. Mathematics has an essential position in human life which we realize or not is often applied in everyday life such as in solving a problem or mathematical operation.

According to Ruseffendi (2006) suggests that mathematics is organized from undefined elements, definitions, axioms, and postulates where postulates after being proven true apply in general, so that is why mathematics is often called deductive science (Ruseffendi, 2006). Mathematical concepts are important to be recognized by students and teachers in education.

Improving the quality of mathematics education is a significant challenge for many countries around the world. `` (1988) and Fuad Hassan (1989) argue that teachers and students are the main factors that influence the success of education. They emphasize the importance of teacher competence and quality to ensure educational success. There are other factors that influence, but their influence is smaller than that of teachers and students.

Shulman states that teachers must have the knowledge and experience to teach well. He adds that it is not enough for a teacher to understand how to teach, but also to have adequate knowledge of the content to be taught. Therefore, extensive knowledge and experience are necessary to ensure success in learning (Shulman, 1986).

The process of forming good mathematics teachers must start with the education process of pre-service teachers. A student mathematics teacher candidate is someone who is studying in an undergraduate or postgraduate program with the aim of becoming a mathematics teacher in the future. Student mathematics teacher candidates usually have an interest and ability in mathematics and want to have a career as a mathematics teacher.

The preparation of pre-service math teachers should be a priority for any education system that wants to achieve success and sustainability. By preparing qualified pre-service mathematics teachers, we can help create a better educational environment and provide better opportunities for students to learn and grow. During their studies, pre-service math teacher students will learn about mathematical theories and concepts, math teaching

methods, educational psychology, as well as classroom management skills. In addition, they will also do internships or teaching practice in schools or other educational institutions as part of their study program. Pre-service mathematics teachers are expected to have a strong understanding of mathematical concepts and the ability to teach these concepts clearly and effectively to students. They are also expected to have good communication skills, the ability to interact with students positively, and effective classroom management skills.

Research as a scientific activity has been conducted by both educational institutions and non-educational institutions. For a long time, research has been carried out, it is necessary to evaluate the results of the research. One method that can be used is bibliometrics and scientometrics introduced by Pritchard, Nalimov, and Mulchenko in 1969 (Singh, 2014). In this study, bibliometrics is considered a suitable method to review the research trends on prospective teachers and mathematical concepts. Bibliometrics is a research method to explore and analyze large volumes of scientific data to present the state of emerging trends in a topic or field (Donthu et al., 2021; Fuad et al., 2022).

Some research on bibliometrics has been done, including researchers (Supriyadi et al., 2022) discussing bibliometrics in mathematics learning research results in Indonesia from the results of the study, there are few studies conducted on mathematics education over the past two years. Currently, the Indonesian University of Education is the most significantly influential association on Scopus index data using R-Studo. In addition, research using Vosviewer (Cahya et al., 2022) illustrates the use of ICT in improving students' mathematical creative thinking skills in the last decade from 2012-2020.

More recently, research by (Muhammad et al., 2023) examining Critical Thinking in mathematics learning showed that there were 100 documents and 111 top citations on the topic from 2017 to 2022 on the Scopus database. From these descriptions, it appears that there are still no bibliometric articles that discuss mathematical concepts in pre-service mathematics teachers so this is an opportunity for researchers to discuss it. Therefore, the purpose of this study is to analyze the performance of metrics related to publications and citations and their trends from the study of "pre-service teacher mathematics", and science mapping and network analysis related to citation analysis, authoring partner analysis, and word partner analysis from the study of "pre-service teacher mathematics".

METHOD

The method used this time is a descriptive method with a bibliometric approach. Bibliometric methodology in its application uses quantitative techniques (Donthu et al., 2021). One of the databases used is the Scopus database, Data analysis is carried out quantitatively and qualitatively, where quantitative includes evaluation and interpretation while qualitative by providing interpretation. The bibliometric analysis consists of 2 techniques, namely 1) the main technique consisting of performance analysis and science mapping and 2) enrichment techniques. The analysis used in this research is a performance analysis and science mapping. The performance analysis conducted includes 1) publication-related metrics, 2) citation-related metrics, and 3) citation-and-publication-related metrics. Science mapping includes 1) citation analysis, 2) co-citation analysis, 3) bibliographic coupling, 4) co-word analysis, and 5) co-authorship analysis. For network analysis,

visualization is presented using VOSviewer software, then network metrics and clustering are analyzed.

Bibliometric analysis has several functions, namely to 1) position the desired contribution in the field, 2) get new ideas for investigation, 3) identify knowledge gaps, and 4) get a one-stop view (Donthu et al., 2021). Some literature states that there are 5 steps to performing the bibliometric analysis (Fahimnia et al., 2015; Setyaningsih et al., 2018). These steps can be seen in Figure 1.
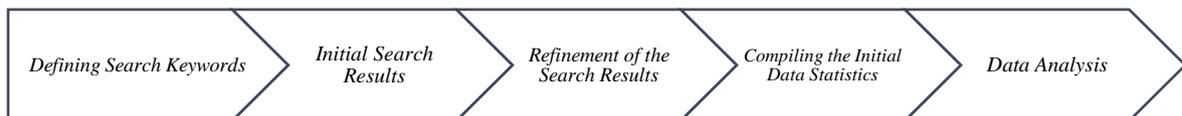

Figure 1. Steps in Bibliometric Analysis

Analyzing the data used in this study. First performance analysis publication and citation-related metric, publication and citation trend analysis. Publication and citation metric analysis are carried out by presenting the results of publication and citation measurements whose data are obtained from Publish or Perish software related to year and total publications, year and total citations, many citations per year and per paper, many authors per document, h-Index, and g-Index.

Second science mapping and network analysis related to science mapping and network analysis are done by conducting citation analysis, co-authorship analysis, and co-word analysis. Performance analysis is used to present the development of publications and citations related to the study of "pre-service teacher mathematics" where PoP software is used to support this analysis. Citation Analysis is used to present the productive and influential documents, authors, sources, and institutions regarding the study of "pre-service teachers".

Co-authorship analysis was used to present the social interaction between authors and their institutions related to the study of "pre-service teacher mathematics". Co-word analysis is used to present the most occurring keywords related to the study of "pre-service teacher mathematics" in the current period. Network visualization, overlay, and density and hierarchical clustering analysis are presented to enrich the citation, co-authorship, and co-word analysis by using VOSviewer software.

RESULTS AND DISCUSSION

The results of this study are the results of performance analysis and network analysis as well as knowledge mapping related to the study research "pre-service teacher mathematics in mathematical concepts".

Performance Analysis

Publication-and-Citation-Related Metrics

Information about citation metrics in this study was obtained from documents obtained from the Scopus database in RIS format which was entered into the PoP software. In Table 1.

Table 1. Publication and Citation Metrics of Documents on "pre-service teacher mathematics"

Description	Result
Year of publication	2017-2022
Citation year	6 (2017-2023)
Total Documents	118
Total document citations	337
Citations/year	56,17
Citations/paper	2,86
Author/paper	1,00
h-Index	10
g-Index	14

From Table 1, it can be seen that the publications produced are in the range of 2017 to 2022 with publications of 118 documents related to 'pre-service teacher mathematics in mathematics concepts and have been cited as many as 337 citations. The average number of citations per year is 56.17 with an average number of citations per document is 2.86 which indicates that each document has been cited about 3 times. The average author per paper is 1. Table 1 above also shows that the h-index score of 10 and the g-index score of 14 are lower than the h-index of 1.2.

Publication and Citation Trend Analysis

This analysis is used to present the development of publications and citations related to pre-service teacher mathematics in mathematics concepts in the period 2017-2022. The development of documents and citations related to their research trends can be seen in Figure 2.
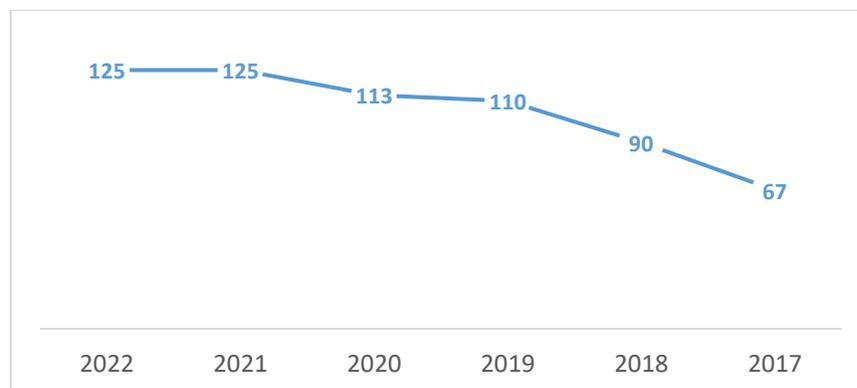

Figure 2. Development of Publications and Citations of Studies on Pre-Service Teacher Mathematics in Mathematical Concepts

From Figure 2 above, 118 documents on pre-service mathematics teachers on mathematical concepts in the range of 2017 to 2022, 67 documents were found in 2017 increasing from year to year to 125 documents in 2022, this shows that the development of publications related to pre-service mathematics teachers on mathematical concepts has increased from 2017 to 2022.

Science Mapping and Network Analysis

Citation Analysis

This citation analysis is used to show productive and influential documents, authors, sources, and institutions related to the research "pre-service teacher mathematics in mathematical concepts" in the range of 2017-2022. To show productive authors, sources, and institutions, a number of document publications are used, while to show influential documents, authors, sources, and institutions, citations are used. The influential documents are represented by the top 10 documents with the highest citations. The complete data can be seen in Table 2.

Table 2. Top 10 Documents with the Most Citations

GS Rank	Title	Authors	Source	Cites	Year
1	Evaluating a course for teaching introductory programming with Scratch to pre-service kindergarten teachers	Stamatios Papadakis, Michail Kalogiannakis	International Journal of Technology Enhanced Learning	45	2019
2	Enhancing noticing: Using a hypothetical learning trajectory to improve pre-service primary teachers' professional discourse	Pedro Ivars, Ceneida FernÃ¡ndez, Salvador Llinares, Ban Heng Choy	Eurasia Journal of Mathematics, Science and Technology Education	27	2018
3	Conceptual bases of use of free software in the professional training of pre-service teacher of mathematics, physics and computer science	Vladyslav Ye Velychko, Elena H. Fedorenko, Darja A. Kassim	CEUR Workshop Proceedings	13	2018
4	Pre-service early childhood teachers' views on STEM education and their STEM teaching practices	Christer Bergsten, Peter Frejd	Research in Science and Technological Education	12	2022
5	Preparing pre-service mathematics teachers for STEM education: an analysis of lesson proposals	AyÅŸe Ã‡iftÃ§i, Mustafa Sami TopÃ§u, Jaimie A. Foulk	ZDM - Mathematics Education	12	2019
6	Case study on mathematics pre-service teachers' difficulties in problem posing	Sarah Bansilal, Deonarain Brijlall, Maria Trigueros	Eurasia Journal of Mathematics, Science and Technology Education	12	2018
7	Exploring the explanation of pre-service teacher in mathematics teaching practice	Wasilatul Murtafiah, Cholis Sa'dijah, Tjang Daniel Candra, Susiswo, Abdur Rahman As'ari	Journal on Mathematics Education	11	2018

8	An APOS study on pre-service teachers' understanding of injections and surjections	Steven Silber, Jinfa Cai	Journal of Mathematical Behavior	11	2017
9	Integrating local wisdom forms in augmented reality application: Impact attitudes, motivations and understanding of geometry of pre-service mathematics teachers'	Sudirman, Mellawaty, R. Poopy Yaniwati, Rully Indrawan	International Journal of Interactive Mobile Technologies	10	2020
10	Pre-service teachers' free and structured mathematical problem posing	Weichao Chen	International Journal of Mathematical Education in Science and Technology	10	2017

Table 2 shows that the most influential document related to the study of pre-service mathematics teachers in mathematical concepts is a document written by Stamatios Papadakis and friends in 2019 with the document title "Evaluating a course for teaching introductory programming with Scratch to pre-service kindergarten teachers" published by the International Journal of Technology Enhanced Learning. To date, the influential document has been cited 45 times by other relevant research documents, with an average citation per year of 11 times.

Co-Authorship Analysis

Co-authorship analysis is used to examine the relationship between social interactions between authors and the development of a research field. Consequently, this analysis was used to present the social relationships between authors as they relate to the study of pre-service teachers of mathematics in mathematical concepts.

Authorship Partners with Author Unit Analysis

This analysis was conducted to identify the authors who appeared the most during this period. First, the unit of analysis was used to present the social interaction between authors by selecting the minimum number of documents for an author as 1 (one) in VOSviewer software. The result is four author clusters, and ten author items in Figure 3.
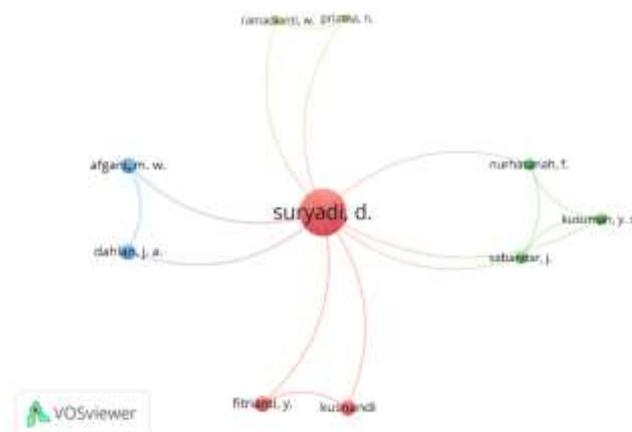

Figure 3. Network Visualization of the Author Analysis Unit on " pre-service teacher mathematics in mathematical concepts "

The figure above shows the network of co-authorship occurrences. Co-authorship indicates whether an author has written a paper with another author. From Figure 4 network visualization of co-authorship above, it can be seen that authors are indicated by name labels and circles. The more the author's contribution, the bigger the name tag and circle. The size of each circle indicates the number of papers written by the author. Any link between two circles indicates that there is collaborative authorship of those authors (co-author). From Figure 4, it can be seen that the largest name tags and circles are Suryadi, d. followed by Kusnandi, fitrianti, y (red color), Dahlan, j.a. and Afgani, m.w. (blue color), Sabandar, J., Kusumah, y. s and Nurhasanah, f. (green color), ramadianti, f. (green color), and f. (green color). (green color), ramadianti, w and priatna, n (yellow color).

As seen in figure 4, the co-authorship of studies related to "pre-service teacher mathematics in mathematical concepts" consists of 4 clusters marked with 4 colors: red (cluster 1), green (cluster 2), blue (cluster 3), and yellow (cluster 4). From the cluster color, it can be seen that Suryadi, d., Kusnandi, Fitrianti, y belong to cluster 1, followed by Sabandar, J., Kusumah, y. s and Nurhasanah, f. belong to cluster 2, then Ishartono, N.; Narimo, S.; Prayitno, H. J.; and Sari, D. P. belong to cluster 3, then Dahlan, j.a. and Afgani, m.w. belong to cluster 4, and finally ramadianti, w, and priatna. Writing partners can be seen for example, Djawa has worked with Saleh and Djawa has worked with Ruhama and Saleh has worked with Im.
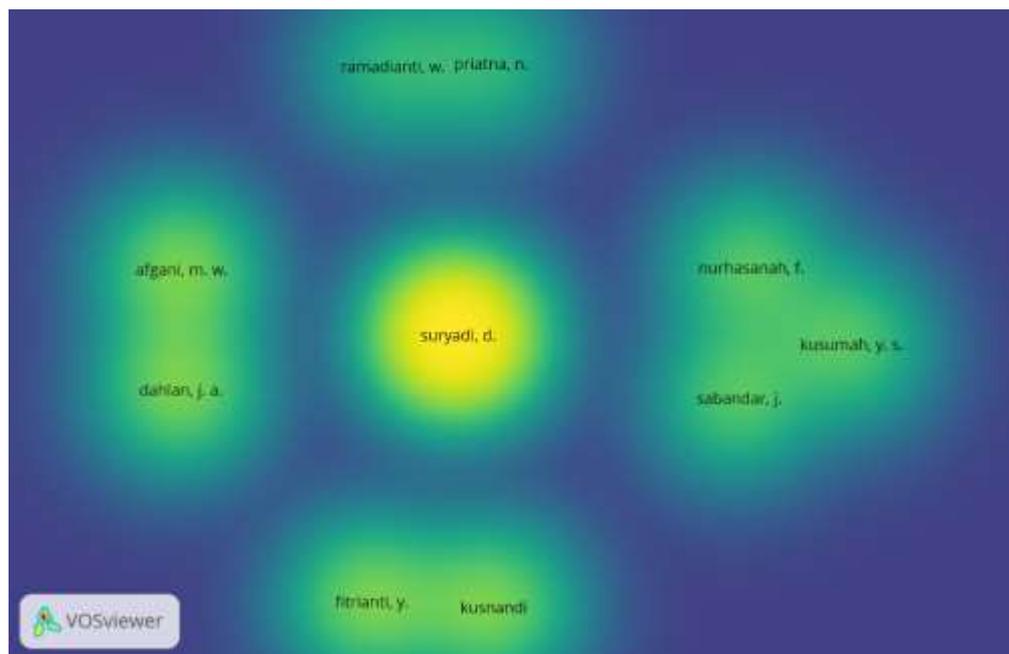

Figure 4. Density Visualization of the Author's Unit of Analysis on "Pre-service Teachers of Mathematics in Mathematical Concepts"

From the density visualization results in Figure 4, the labels and circles that are the largest and thickest in color are Suryadi, D, followed by Kusnandi, Fitrianti, y., and so on. This indicates that Suryadi, D., is the author with the most authorship partners.

Co-word Analysis

This analysis is used to determine the keywords in the paper that appear frequently. The VOSviewer application is used to visualize the bibliometric map with full counting done with the minimum number of occurrences of a keyword being two times, resulting in 325 keywords and 30 thresholds. With the VOSviewer application, we found as many as 30 items, 6 clusters. A total of 118 items divided into 6 clusters can be seen in detail in the following description:

i.   Cluster 1 has 7 items and is marked in red. These items are concept map, elementary school, mathematics, mathematics teaching, online learning, pre-service teacher, and pre-service teacher education. The most frequent item in cluster 1 is a pre-service teacher which has 5 links, 9 total link strengths, and 8 occurrences.

ii. Cluster 2 has 6 items and is marked in green. The items are Common content knowledge, concept image, design-based research, function, pre-service teacher, and teacher knowledge. The most frequently occurring item in cluster 2 is a pre-service teacher which has 13 links, 16 total link strengths, and 23 occurrences.

iii. Cluster 3 has 5 items and is marked in blue. The items are geometry, pedagogical content knowledge, pre-service mathematics teacher, professional development, and stem education. The most frequently occurring item in cluster 3 is pre-service mathematics teacher which has 10 links, 11 total link strengths, and 10 occurrences.

iv. Cluster 4 has 5 items and is marked in yellow. The items are fractions, mathematics education, problem posing, problem-solving, and teacher training. The most frequently occurring item in cluster 4 is mathematics education which has 9 links, 10 total link strengths, and 7 occurrences.

v.   Cluster 5 has 3 items and is marked in purple. These items include limits, manipulatives, and pre-service teachers. Each Item appearing in cluster 5 has 2 links, 2 total link strengths, and 2 occurrences.

vi. Cluster 6 has 2 items and is marked with cyan color. These items are infinity and teacher education. The most frequently occurring item in cluster 6 is teacher education which has 2 links, 2 total link strengths, and 4 occurrences.

The relationship between one term and another is shown for each cluster. Labels are assigned to each term with colored circles. The size of the circle label shows a positive correlation with the occurrence of the term in the title and abstract. The more the term appears, the larger the size of the circle label. A visualization map of the clusters and their terms analyzed with VOSviewer software can be seen in the figures below. These figures show the relationship between the terms as shown in the interconnected network. The figures also show the cluster of each frequently researched term related to the research topic 'pre-service teachers of mathematics in mathematical concepts' in Figure 5.
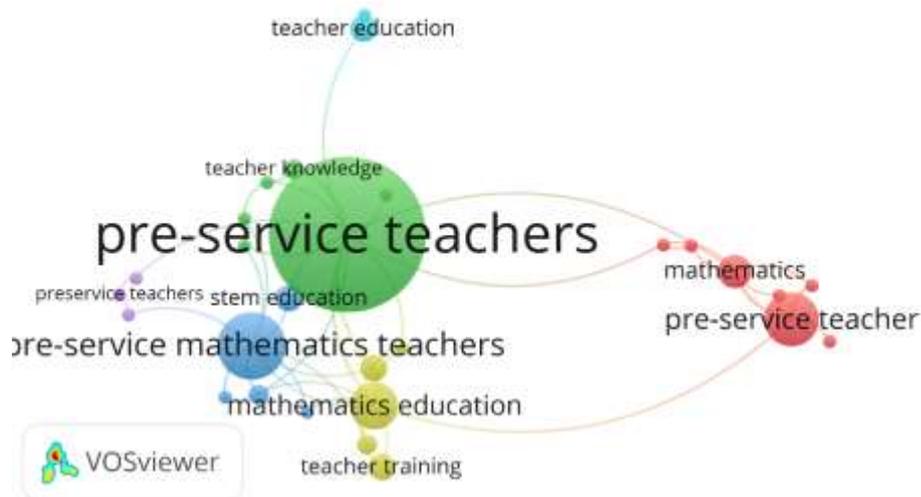
Figure 5. Network Visualization of Keyword Co-occurrence on "pre-service in Mathematics Learning"

From the network visualization in Figure 5, it can be seen that the clusters of research on pre-service teacher mathematics in mathematics concepts can be divided into 3 areas with the terms pre-service teacher or pre-service mathematics teacher. The first term, 'pre-service teacher included in clusters 1 and 2 has 13 links, 16 total link strengths, and 23 occurrences. In detail, a visual of these relationships can be seen in Figure 6.
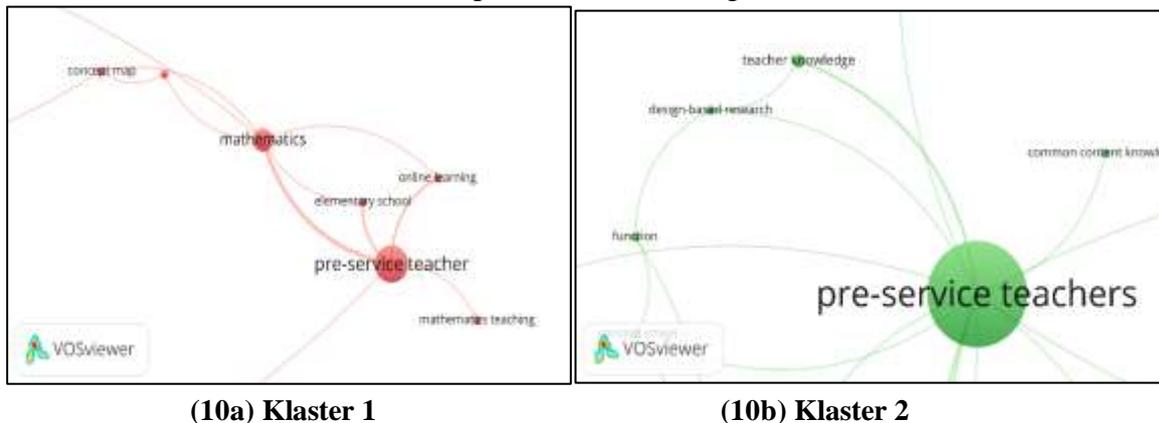

(10a) Klaster 1

(10b) Klaster 2

Figure 6. Visualization of Keyword Occurrence Network on "pre-service teacher in Mathematics concept" Cluster 1 and 2

The figure above shows the network of relationships of the term 'pre-service teacher' with other terms connected by links. These terms include concept map, elementary school, mathematics, mathematics teaching, online learning, pre-service teacher, pre-service teacher education, common content knowledge, concept image, design-based research, function, pre-service teacher, and teacher knowledge.

vii) For the second term, 'pre-service mathematics teacher' belongs to cluster 3 which has 10 links, 11 total link strengths, and 10 occurrences in Figure 7.
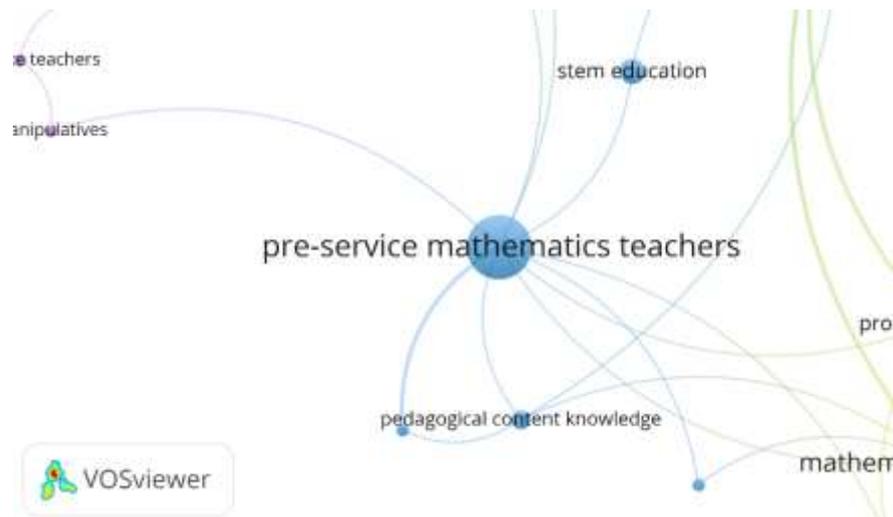
Figure 7. Network Visualization of Keyword Occurrence of "pre-service mathematics teachers" in Cluster 3

Figure 7 shows the network relationship of the term 'pre-service mathematics teachers' with other terms connected by links. These terms include geometry, pedagogical content knowledge, pre-service mathematics teacher, professional development, and stem education.

The density visualization shows that the brighter the yellow color and the larger the diameter of the circle label, the more often the term appears. This means that many studies use the term, in the case of Figure 8 is the term 'pre-service'.
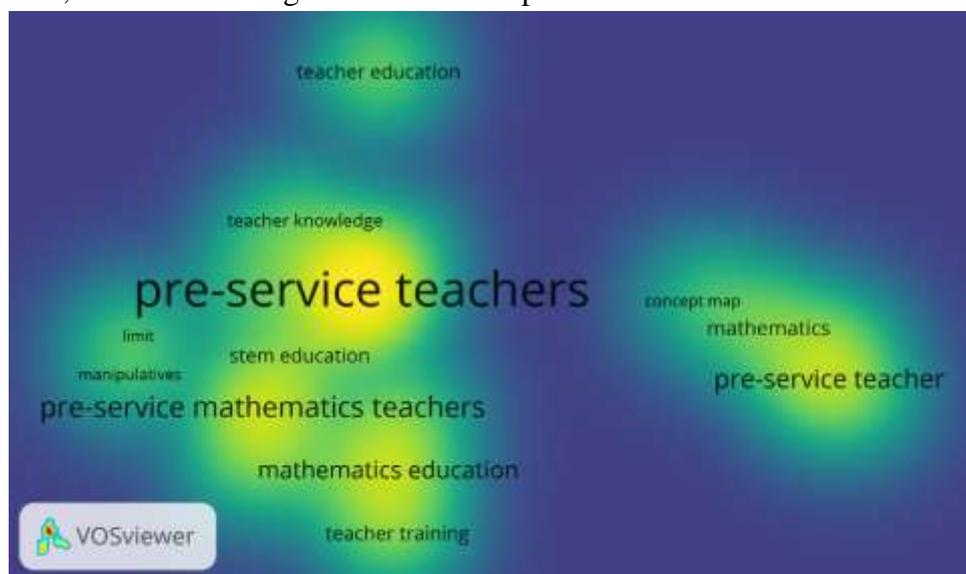

Figure 8. Visualization of Density of keyword co-occurrence in pre-service mathematics teachers.

Then conversely, if the yellow color is fading then the number of studies on the term is getting less. In Figure 8, it can be seen that studies related to the terms pre-service teacher, and pre-service mathematics teacher have a high number of studies.

Figure 9 shows the overlay visualization in 'pre-service mathematics teachers'. From the figure, it can be seen that research on 'pre-service mathematics teachers' was conducted

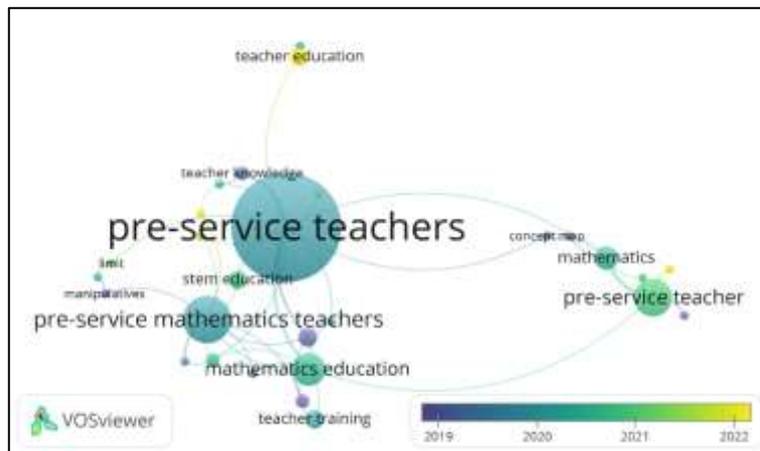in 2020. Most research was conducted in 2020 as seen from the image which is dominated by green color.

Figure 9. Overlay visualization of keyword co-occurrence in pre-service mathematics teachers.

Research on pre-service mathematics teachers in mathematics learning started a long time ago (Fairthrone, 1969), but the studies have increased in recent years. Some research suggests a deep understanding of key mathematical concepts to be better prepared for a future teaching career (Bowie et al., 2019).Knowledge of mathematical concepts taught is key to mastery of content knowledge skills in teacher education programs at some universities (GUIDE, n.d.). A good understanding of mathematics content knowledge is very important for prospective mathematics teachers in teaching mathematics (Shulman, 2019), so it can have an impact on efforts to improve professionalism and develop a number of mathematical abilities and skills (Novita, Herman, Suryadi, Dasari, & Putra, 2022). Teachers are also very instrumental in encouraging their students to develop mathematical knowledge through inquiry, exploration, hypothesis checking, approaches, problem-solving processes, research, and discussion of ideas (National Council of Teachers of Mathematics, 2014). teachers' mathematical knowledge has a high contribution to students' mathematics achievement (Ayebale et al., 2020). So that the cultivation of conceptual knowledge in the minds of students can be realized and ultimately students have sufficient competence to solve all types of problems and tasks. Good mastery and understanding of mathematics by prospective student teachers are expected to help them demonstrate and apply their knowledge to plan and manage mathematics learning well later (Novita, Herman, Suryadi, Dasari, Putra, et al., 2022).

Students learn math through experiences and problems provided by teachers in the classroom. To ensure effective mathematics learning, teachers must master the mathematics content they teach. However, a number of studies have shed light on prospective teachers' mastery of mathematics content (Aguilar & Telese, 2018; Bullock et al., 2021; Güven & Özmen, 2022; Hendracipta et al., 2021). One of the important math concepts for prospective teachers is ratio and proportion material (Ben-Chaim et al., 2012; Irfan et al., 2019).

However, it is still possible for us to create new research on 'pre-service mathematics teachers, especially if we combine it with the cultural context and mathematics content. The implication of this research is that the academic community can know the trends and growth patterns of knowledge about pre-service mathematics teachers that have developed to date.

This includes estimating the productivity of publications, authorship, citations, affiliations, and related disciplines. One of the keywords in the research of prospective mathematics teachers is the importance of understanding mathematical concepts.

CONCLUSION

Based on the description of the results and discussion, it is concluded that there are 118 publications related to the study of "pre-service mathematics teachers" in the range of 2017-2022 with 322 citations that are fluctuating... The language used in the study entirely uses English with the majority, Visualization Network co-authorship emergence is Suryadi from Indonesia. While the occurrence of keywords (co-occurrence) often appears among others teacher knowledge, concept map, professional development, stem education, and content mathematics. Research on pre-service teachers" and "mathematics concepts" has grown rapidly in the last five years, but there is still a gap for researchers to make new research as a development of previous research.

For this reason, research targeting pre-service mathematics teachers is important to design the mastery of content mathematics material so as to produce qualified and professional prospective mathematics teacher graduates. Didactic Design Research (DDR) models can be implemented in future studies of prospective mathematics teachers not least in the field of education and especially the field of mathematics education in the college curriculum.

REFERENCES

Aguilar, J., & Telese, J. A. (2018). Mathematics understanding of elementary pre-service teachers: The analysis of their procedural-fluency, conceptual-understanding, and problem-solving strategies. *Mathematics Teaching-Research Journal*, *10*(3–4), 24–37.

Ayebale, L., Habaasa, G., & Tweheyo, S. (2020). Factors affecting students' achievement in mathematics in secondary schools in developing countries: A rapid systematic. *Statistical Journal of the IAOS*, *36*(S1), S73–S76. https://doi.org/10.3233/sji-200713

Ben-Chaim, D., Keret, Y., & Ilany, B. S. (2012). Ratio and proportion: Research and teaching in mathematics teachers' education (Pre- and in-service mathematics teachers of elementary and middle school classes). In *Ratio and Proportion: Research and Teaching in Mathematics Teachers' Education (Pre- and In-Service Mathematics Teachers of Elementary and Middle School Classes)*. https://doi.org/10.1007/978-94-6091-784-4

Bullock, E., Ray, A., Herron, J., & Swarthout, M. (2021). The GMaV Conceptual Framework: Constructing Elementary Pre-Service Teacher's Mathematics Vocabulary Understanding through Contextualized Guided Notes. *Investigations in Mathematics Learning*, *13*(4), 287–302. https://doi.org/10.1080/19477503.2021.1985906

Cahya, M.Y.P. et al. (2022) 'Penggunaan ICT Dalam Meningkatkan Kemampuan Berpikir Kritis Matematis Siswa Dekade Terakhir: Sebuah Analisis Bibliometrik', Joornal of Songke Math, 5(2), pp. 34–47.

Donthu, N. et al. (2021) 'How to conduct a bibliometric analysis: An overview and guidelines', Journal of Business Research, 133(April), pp. 285–296. Available at: https://doi.org/10.1016/j.jbusres.2021.04.070.

Fahimnia, B., Sarkis, J. and Davarzani, H. (2015) Green supply chain management: A review

and bibliometric analysis, International Journal of Production Economics. Elsevier. Available at: https://doi.org/10.1016/j.ijpe.2015.01.003.

Fairthrone, R.A. (1969) 'Empirical Hyperbolic Distributions (Bradford-Zipf-Mandelbrot) for Bibliometric Description and Prediction', Journal of Documentation, 2(4), pp. 319–343.

Fuad, M. et al. (2022) 'A Bibliometric Analysis of Technology-Based Foreign Language Learning during the COVID-19 Pandemic: Direction for Indonesia Language Learning', International Journal of Information and Education Technology, 12(10), pp. 983–995. Available at: https://doi.org/10.18178/ijiet.2022.12.10.1710.

Güven, B., & Özmen, Z. M. (2022). Enhancing pre-service mathematics teachers understanding of sampling distributions with conceptual change texts. *Journal of Pedagogical Research*, 6(1), 110–130. https://doi.org/10.33902/jpr.2022175561

Hendracipta, N., Rafianti, I., Pujiastuti, H., & Haryadi, R. (2021). The use of augmented reality to improve mathematics conceptual understanding of pre-service elementary education teachers. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1796, Issue 1). https://doi.org/10.1088/1742-6596/1796/1/012018

Hidayat, M.R., Irvansyah, M. and Melati, S.A. (2023). Kesiapan Perguruan Tinggi Dalam Mendidik Calon Guru Matematika untuk Mengajar di Era Society 5.0. in ProSANDIKA UNIKAL (Prosiding Seminar Nasional Pendidikan Matematika Universitas Pekalongan), pp. 539–546.

Irfan, M., Nusantara, T., Subanji, Sisworo, Wijayanto, Z., & Widodo, S. A. (2019). Why do pre-service teachers use the two-variable linear equation system concept to solve the proportion problem? *Journal of Physics: Conference Series*, *1188*(1), 12013. https://doi.org/10.1088/1742-6596/1188/1/012013

Novita, R., Herman, T., Suryadi, D., Dasari, D., & Putra, M. (2022). How Pre-Service Elementary Teachers Deal with Mathematical Literacy Problems? A Case Study. *Proceedings of the Eighth Southeast Asia Design Research (SEA-DR) & the Second Science, Technology, Education, Arts, Culture, and Humanity (STEACH) International Conference (SEADR-STEACH 2021)*, *627*, 135–143. https://doi.org/10.2991/assehr.k.211229.022

Novita, R., Herman, T., Suryadi, D., Dasari, D., Putra, M., & Fitra, R. (2022). Analisis Pengetahuan Konseptual dan Prosedural Mahasiswa Calon Guru Sekolah Dasar Pada Bilangan Rasional. *JNPM (Jurnal Nasional Pendidikan Matematika)*, *6*(2), 384. https://doi.org/10.33603/jnpm.v6i2.7056

Muhammad, I. et al. (2023) 'Analisis Bibliometrik: Fokus Penelitian Critical Thinking dalam Pembelajaran Matematika (2017–2022)', JPMI (Jurnal Pembelajaran Matematika Inovatif), 6(1), pp. 78–84.

Ruseffendi (2006) 'Membantu Guru Mengembangkan Kompetensinya dalam pembelajaran matematika untuk meningkatkan', Bandung: tarsito, pp. 49–51.

Setyaningsih, I., Indarti, N. and Ferry, J. (2018) 'Bibliometric analysis of the term "green manufacturing"', International Journal of Management Concepts and Philosophy, 11(3), pp. 315–339. Available at: https://doi.org/doi: 10.1504/ijmcp.2018.093500.

Shulman, L.S. (1986) 'Those Who Understand: A Conception of Teacher Knowledge.', American Educator, 10(1), pp. 4–14.

Shulman, L. S. (2019). Those who understand: Knowledge growth in teaching. *Profesorado*, *23*(3), 269–295. https://doi.org/10.30827/profesorado.v23i3.11230

Singh, J.K. (2014) 'A Scientometric analysis of " Indian Journal of Pure and Applied Physics " (2006- 2010): A study based on Web of Science A Scientometric analysis of " Indian Journal of Pure and Applied Physics " (2006-2010): A study based on Web of Science', Research Journal of Library Sciences, 2(1), pp. 7–12.

Supriyadi, E. et al. (2022) 'Bibliometric analysis of learning mathematics studies from Indonesian authors', Jurnal Kajian Pembelajaran Matematika, 6(2), p. 84. Available at: https://doi.org/10.17977/um076v6i22022p84-95.

Trapsilasiwi, D., Jhahro, K.F. and Setiawan, T.B. (2018) 'Pemahaman Konsep Siswa Pada Pemecahan Masalah Soal Geometri Pokok Bahasan Segiempat Ditinjau Dari Gaya Kognitif Reflektif-Impulsif Siswa', Kadikma, 9(1), pp. 116–122.