

RESEARCH ON ALGEBRAIC THINKING IN ELEMENTARY SCHOOL IS REDUCED: A BIBLIOMETRIC ANALYSIS

RIDUAN FEBRIANDI*, TATANG HERMAN, T. TURMUDI,
LAELY FAROKHAH, ZAENAL ABIDIN, A. ALMAN, EDI SUPRIYADI

Universitas Pendidikan Indonesia, Jl. Setiabudhi No.229, Bandung Indonesia

*Corresponding Author: riduanfebriandi@upi.edu

Abstract

The purpose of this research is to find out the development of research on the algebraic thinking skills of elementary school students. The method used in this study uses a bibliometric approach based on computational mapping analysis assisted by VOSviewer, based on searches from the Google Scholar database, and the title of the article is used as a guide in the search process which is obtained from the keyword "Thinking Algebra in Elementary Schools". From the search results, 996 articles were obtained from search results on Google Scholar using Publish or Perish that were relevant to the algebraic thinking of elementary school students from the last 10 years (2012-2021). The results showed a decline in research related to elementary school students' algebraic thinking or early algebra. From the analysis of articles using VOSviewer, the development of publications occurred in 2012-2013, from 99 to 141 publications, but decreased in 2014 to 115 publications. In 2013 there was an increase in the number of publications, namely 137 articles published on Google Scholar. From 2013 to 2022, the number of articles on the topic of algebraic thinking in elementary school or early algebra continued to decline. It can also be seen from the articles written by researchers around the world in the last 10 years, only the US has done a lot of research on algebraic thinking. The conclusions of this study will be a new object for researchers in conducting research that will be related to algebraic thinking with different variables, especially in elementary schools.

Keywords: Algebraic thinking, Analysis, Bibliometric, Elementary school, Publish or Perish, VOSviewer.

1. Introduction

Bibliometric analysis has now proven to be an effective tool in studying research phenomena and advances in various research fields and contributes to providing an updated perspective on research boundaries and trends [1-4]. Searching for certain topics that have a great opportunity to be researched and looking for references that are most widely used in certain fields using VOSviewer in the bibliometric analysis [5].

Many studies have been conducted in the field of education [6, 7], one of which is research in the field of algebraic thinking in mathematics subjects. Algebraic thinking is very fundamental in elementary school mathematics. that algebraic thinking is the use of multiple representations to present, generalize, and solve a quantitative situation [8]. Many reports from research results discuss algebraic thinking, that algebraic thinking is a skill to focus on the relationship between numbers [9, 10]. Despite the important role of algebraic thinking, it is still considered a difficult skill in teaching and learning [11, 12]. Algebra is the key to success in advanced mathematics. In life or the world of work, algebra plays an important role in solving problems that often arise and must be solved using algebra. However, research related to mapping bibliometric analysis of algebraic thinking in elementary schools has not been carried out in the last 10 years. Therefore, this research was conducted to map the results of an article publication using bibliometric analysis searched in Google Scholar and then reduced using VOSviewer software. This research was conducted to be able to contribute ideas to researchers in determining research topics, especially by thinking about algebra in elementary schools. From the research of Nurmawanti and Sulandra [13], it is stated that the results of the research conducted can be used in developing strategies for learning mathematics so that students' algebraic thinking skills develop. The next recent finding is that there is a correlation between elementary school mathematics and algebra, this shows that in elementary school students have been touched by informal algebra. And others also found that research related to algebraic thinking in elementary school mathematics has not been done much and it is very urgent to do it because in elementary school children already know algebra.

2.2. Method

The article data collected is based on journals indexed by Google Scholar because it is open source. In searching for publication data on Google Scholar, a reference manager application was used by several previous researchers, namely, Publish or Perish (PoP). PoP software works to collect articles related to the chosen topic, namely algebraic thinking in elementary schools from Google Scholar [14, 15]. The stages of research are carried out in the following way:

- (i) The initial stage is the collection of publication data from Google Scholar using Publish or Perish,
- (ii) Second stage Mapping bibliometric data for the last 10 years using Microsoft Excel application,
- (iii) The third stage of the bibliometric mapping analysis process from the published data collected using the VOSviewer application,
- (iv) Analysis of results from data visualization.

The search data used the keyword "Thinking Algebra in Elementary School" from Google Scholar. The articles collected are based on the range from 2012 to 2022. The articles found from the PoP application have been matched to the related keywords and are then exported into two types of files: research information system (.ris) and value format separated by commas (*). .csv). then VOSviewer is used to analyse and visualize related and mapped research results.

There are 3 variations of mapping publications that are visualized based on the VOSviewer application, namely network visualization, density visualization, and overlay visualization of the selected item. From 996 articles found, 161 relevant terms or keywords were obtained for bibliometric analysis in producing a new research topic related to algebraic thinking in elementary school.

3.Results and Discussion

From the search results of article publications through archive management using Publish or Perish software sourced from the Google Scholar database, 996 article data were obtained that were relevant to the keyword thinking algebra, to understand the main content of an article, the author's keyword analysis was carried out [16, 17]. The data collected is a collection of articles from the last 10 years that includes all article components, starting from the article publisher, title, author identity, number of citations, and links to articles and journals. Table 1 shows us that there are several examples taken from the publications collected and carried out processing or data analysis using VOSviewer. The data samples taken were 22 of the best articles with the latest and most popular criteria by having the most citations that were used as references by researchers for the last 10 years. The 2nd best articles from each year were selected, from 2012 to 2022 which were relevant to the topic that was the keyword in this research, namely algebraic thinking in elementary school.

Development of research from 2012 to 2022 related to the topic of algebraic thinking in elementary schools. Based on the data shown in table 2, 996 studies have been successfully collected through the PoP application. In 2012 there were 99 articles and increased in 2013 to 141 article publications. There was a decrease in article publications in 2014 which was 115 articles and then an increase in publications in 2015 to 137 article publications. And in 2016 it decreased to 118 and then decreased in 2022 to 18 articles.

Figure 1 shows a curve for the decline in the number of publications from 2016 to 2022. 2015 was the last increase in publications related to algebraic thinking in elementary schools. In 2021 and 2022, respectively, there are only 21 and 18 publications, from the previous year having achieved the most publications in 2013 as many as 141 articles.

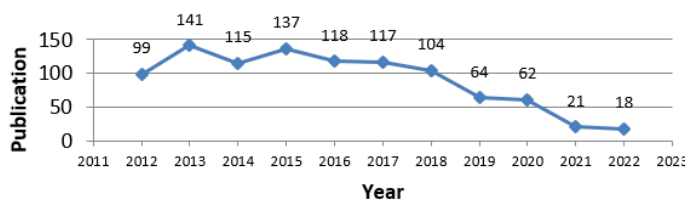


Fig. 1. Level development algebraic thinking in elementary school research

Table 1. Algebraic thinking publication data in elementary school.

No.	Author	Title	Year
1	Radford	On the development of early algebraic...	2012
2	Fuchs et al.	Contributions of domain-general cognitive resources and different forms of arithmetic	2012
3	Hackenberg	The fractional knowledge and algebraic reasoning of students with the first	2013
4	Walkington et al.	Supporting algebraic reasoning through personalized story scenarios: How situational	2013
5	Radford	The progressive development of early embodied algebraic thinking	2014
6	Jupri et al.	Difficulties in initial algebra learning in Indo	2014
7	Radford	Early algebraic thinking: Epistemological, semiotic, and developmental issues	2015
8	Byrd et al.	A specific misconception of the equal sign acts as a barrier to children's learning algebra	2015
9	Siew et al.	Students' algebraic thinking and attitudes...	2016
10	Knuth et al	Build an early foundation for algebra success	2016
11	Bastable et al.	Classroom stories: Examples of elementary students engaged in early algebra	2017
12	Carraher	Early algebra is not the same as algebra early	2017
13	Radford	The emergence of symbolic algebraic thinking in primary school	2018
14	Kieran et al.	Teaching and learning algebraic thinking...	2018
15	Bråting et al.	Development of algebraic thinking: opportunities offered by the Swedish	2019
16	Blanton et al.	Does early algebra matter? The effectiveness of an early algebra intervention in grades 3 to 5	2019
17	Apsari et al.	Geometry Representation to develop algebraic thinking: A recommendation for	2020
18	C Kieran	Algebra teaching and learning	2020
19	Pinto, and Cañadas	Generalizations of third and fifth graders within a functional approach to early	2021
20	Powell et al.	Alternative paths to improved word-problem performance: An advantage for embedding	2021
21	Lim	An analysis of 3rd graders' problem solving strategies on early algebra	2022
22	Pinto et al.	Functional relationships evidenced and representations used by third graders within...	2022

The decline experienced during the last 6 years has become an important phenomenon and must be observed together. Thus, it becomes a great opportunity

for researchers to conduct research. The publication of only 18 articles in 2022, is a very small number.

The VOSviewer application managed to map many articles to make it easier for researchers to reduce articles based on certain items. From these results, 161 items related to algebraic thinking in elementary schools were selected which were divided into 8 clusters. Cluster mapping is described in Fig. 2.

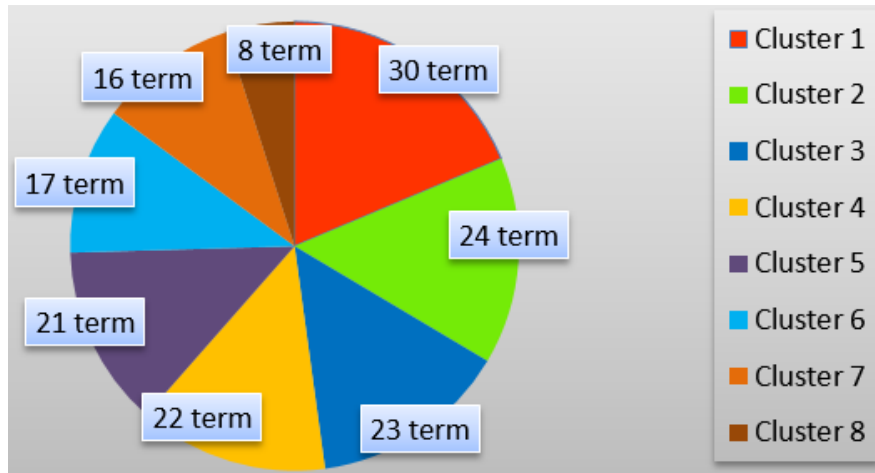


Fig. 2. Topic Research On Algebraic Thinking In Elementary School.

Mapping visualization in this study was analysed with 3 schemes, namely network visualization, overlay visualization, and density visualization. The relationship between terms visualized in the form of a network or line comes from one term to another [18]. As shown in Fig. 3, some circles have different colours, circle sizes, and labels that are connected by a line. The size of the labelled circle shows a positive correlation with the appearance of the term in the title and abstract.

The density visualization shown in Fig. 4 shows that many studies related to algebraic thinking were carried out from 2012 to 2015. Meanwhile, the density visualization shown in Fig. 5 explains that, if the yellow colour is more applied then the research has been carried out a lot, and conversely if the yellow colour is dark or fades and blends with the background it means that research on this topic is very little [19-21].

After being visualized in general, it is illustrated from the results of network visualization that can show us clearly very few relationships and have great opportunities for a recent study. There is a correlation between algebraic thinking and initial algebraic thinking. The correlation of the green circle on the initial algebraic thinking label is small and this has opportunities for research on pre-algebraic thinking. From the network visualization, research related to algebraic thinking in elementary school mathematics has not been done much and it is very urgent to do it because in elementary school children are familiar with early algebra and can already build a foundation in algebraic thinking.

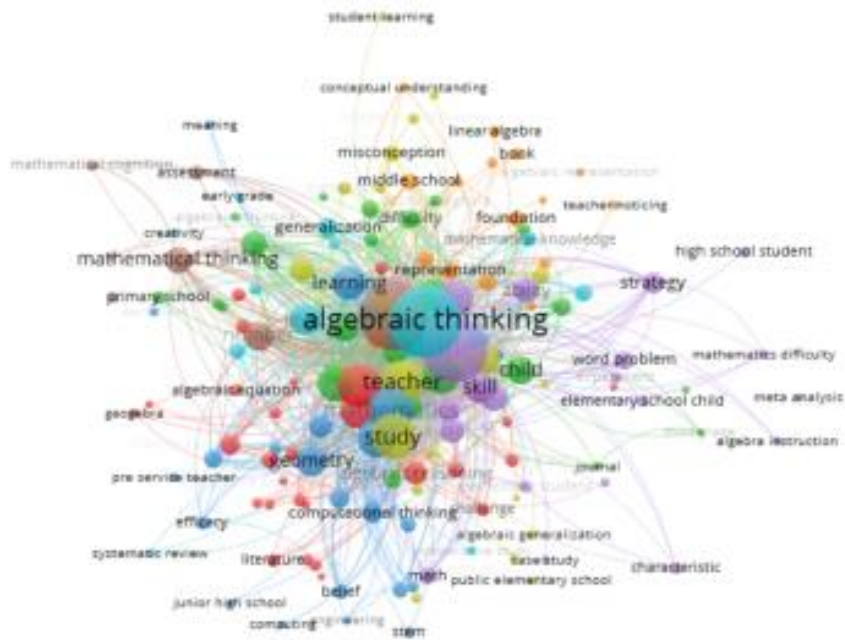


Fig. 3. Network Visualization

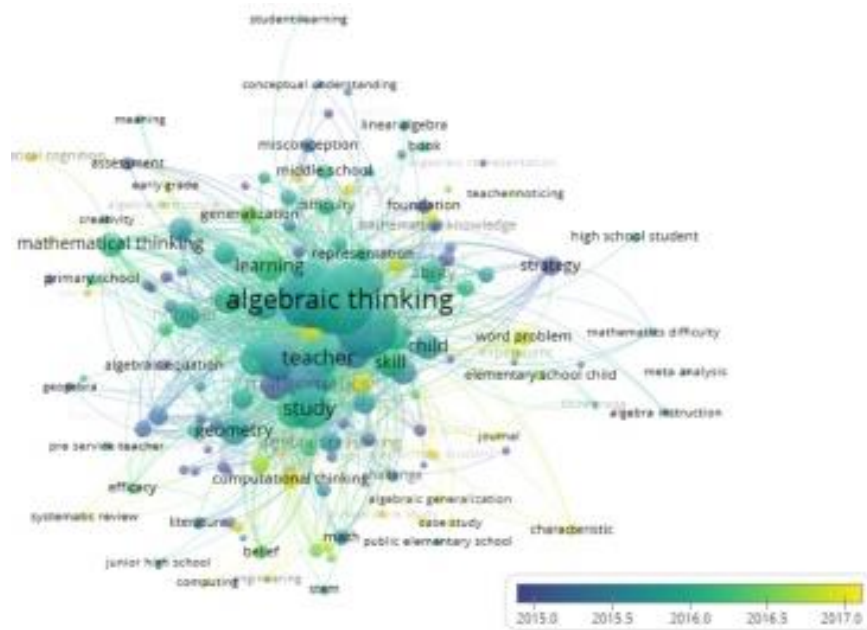


Fig. 4. Overlay Visualization

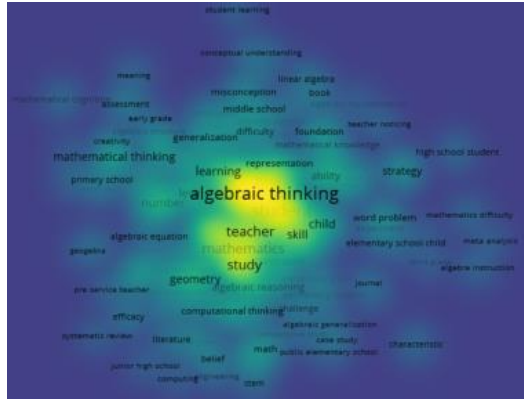


Fig. 5. Density Visualization

4. Conclusion

The research was conducted by analysing the publication of articles with the keywords "Thinking Algebra in Elementary School" which was taken in the last 10 years (2012-2022). 996 articles were collected from Google Scholar through the Publish or Perish software and the 161 best articles based on the most citations were analysed using VOSviewer. From the results of this analysis, it can be seen that there has been a decline in article publications over the last 6 years until now in 2022 only 18 publications, it can be concluded that the opportunity for research on algebraic thinking in elementary schools has a very high chance for research related to other terms.

References

1. Chen, C. (2004). Searching for intellectual turning points: Progressive knowledge domain visualization. *Proceedings of The National Academy of Sciences*, 101(1), 5303-5310.
2. Wang, M.H.; Li, J.; and Ho, Y.S. (2011). Research articles published in water resources journals: A bibliometric analysis. *Desalination and Water Treatment*, 28(1-3), 353-365.
3. Sinha, B. (2012). Global biopesticide research trends: A bibliometric assessment. *Indian Journal of Agricultural Sciences*, 82(2), 95-101.
4. Zhuang, Y.; Liu, X.; Nguyen, T.; He, Q., and Hong, S. (2013). Global remote sensing research trends during 1991–2010: A bibliometric analysis. *Scientometrics*, 96, 203-219.
5. Nandiyanto, A.B.D.; Biddinika, M.K., and Triawan, F. (2020). How bibliographic dataset portrays decreasing number of scientific publication from Indonesia. *Indonesian Journal of Science and Technology*, 5(1), 154-175.
6. Al Husaeni, D.F.; Nandiyanto, A.B.D.; and Maryanti, R. (2023). Bibliometric analysis of educational research in 2017 to 2021 using VOSviewer: Google scholar indexed research. *Indonesian Journal of Teaching in Science*, 3(1), 1-8.
7. Febriandi, R. (2020). Upaya meningkatkan hasil belajar matematika melalui pendekatan scientific dengan pembelajaran cooperative learning pada siswa kelas IV sekolah dasar. *Journal of Elementary School (JOES)*, 3(1), 29-37.

8. Permatasari, D. (2021). Analisis kesulitan siswa dalam kegiatan transformasional berpikir aljabar. *Jurnal Gantang*, 6(1), 19-27.
9. Kieran, C. (2004). Algebraic thinking in the early grades: What is it. *The Mathematics Educator*, 8(1), 139-151.
10. Widodo, S.A.; Prahmana, R.C.I.; and Purnami, A.S. (2017). Teaching materials of algebraic equation. In *Journal of Physics: Conference Series*, 943(1), 012017.
11. Jupri, A.; Drijvers, P.; and van den Heuvel-Panhuizen, M. (2014). Difficulties in initial algebra learning in Indonesia. *Mathematics Education Research Journal*, 26, 683-710.
12. Capraro, M.M.; and Joffrion, H. (2006). Algebraic equations: Can middle-school students meaningfully translate from words to mathematical symbols?. *Reading Psychology*, 27(2-3), 147-164.
13. Nurmawanti, I.; and Sulandra, I.M. (2020). Exploring of student's algebraic thinking process through pattern generalization using similarity or proximity perception. *Mosharafa: Jurnal Pendidikan Matematika*, 9(2), 191-202.
14. Azizah, N.N.; Maryanti, R.; and Nandiyanto, A.B.D. (2021). How to search and manage references with a specific referencing style using google scholar: From step-by-step processing for users to the practical examples in the referencing education. *Indonesian Journal of Multidisciplinary Research*, 1(2), 267-294.
15. Anwar, V.N.; and Herman, T. (2022). Analisis bibliometrik tren publikasi pendekatan stem berbasis computational thinking dalam pembelajaran matematika. *JPMI (Jurnal Pembelajaran Matematika Inovatif)*, 5(5), 1387-1396.
16. Tajudeen, F.P.; Bahar, N.; Maw Pin, T.; and Saedon, N.I. (2022). Mobile technologies and healthy ageing: A bibliometric analysis on publication trends and knowledge structure of mHealth research for older adults. *International Journal of Human-Computer Interaction*, 38(2), 118-130.
17. Galeria, D., & Kaur, G. (2021). Bibliometric analysis of ecopreneurship using VOSviewer and RStudio bibliometrix, 1989–2019. *Library Hi Tech*, 39(4), 1001-1024.
18. Nandiyanto, A.B.D.; Al Husaeni, D.N.; and Al Husaeni, D.F. (2021). A bibliometric analysis of chemical engineering research using vosviewer and its correlation with covid-19 pandemic condition. *Journal of Engineering Science and Technology*, 16(6), 4414-4422.
19. Al Husaeni, D.F.; and Nandiyanto, A.B.D. (2022). Bibliometric computational mapping analysis of publications on mechanical engineering education using vosviewer. *Journal of Engineering Science and Technology*, 17(2), 1135-1149.
20. Soegoto, H.; Soegoto, E.S.; Luckyardi, S.; and Rafdhi, A.A. (2022). A bibliometric analysis of management bioenergy research using vosviewer application. *Indonesian Journal of Science and Technology*, 7(1), 89-104.
21. Al Husaeni, D.F.; and Nandiyanto, A.B.D. (2022). Bibliometric using VOSviewer with publish or perish (using google scholar data): From step-by-step processing for users to the practical examples in the analysis of digital learning articles in pre and post covid-19 pandemic. *ASEAN Journal of Science and Engineering*, 2(1), 19-46.